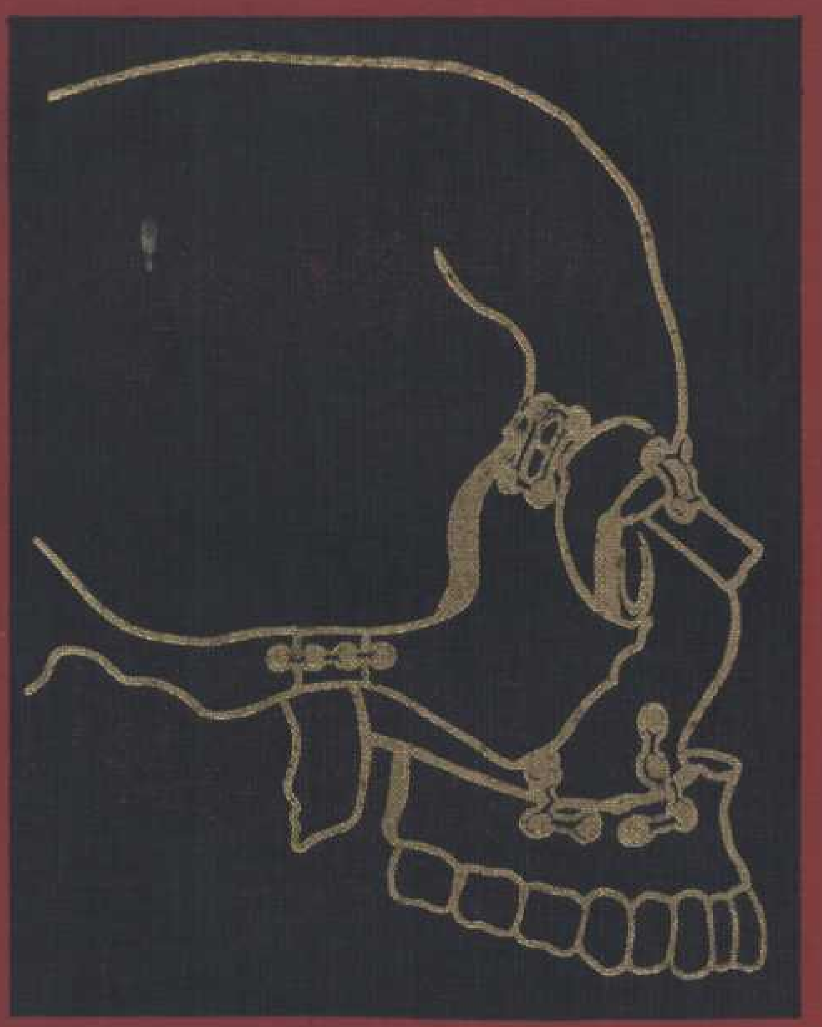


ATLAS OF CRANIOMAXILLOFACIAL FIXATION

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RAVEN PRESS

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Raven Press New York

Raven Press, Ltd., 1185 Avenue of the Americas, New York, New York 10036

Made in the United States of America

Library of Congress Cataloging-in-Publication Data

Kellman, Robert M.
Atlas of craniomaxillofacial fixation / Robert Kellman,
Lawrence Marentette.
p. cm.
Includes bibliographical references and index.
ISBN 0-7817-0016-7
1. Facial bones—Fractures—Atlases. 2. Facial bones—Surgery—Atlases. 3. Fracture fixation—Atlases. I. Marentette, Lawrence.
II. Title.
[DNLM: 1. Maxillofacial Injuries—surgery—atlases. 2. Skull Fractures—surgery—atlases. 3. Fracture Fixation—methods—atlases.
WE 17 K296a 1994]
RD523.K45 1994
617.5'2059—dc20
DNLM/DLC
for Library of Congress 94-18125
CIP

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To our families for their patience and understanding;
to our residents and students who stimulated us to produce
this atlas; and to our teachers, Professor Bernd Spiessl (RK)
and Professor Hugo Obwegeser (LM), who provided us with our
foundation of knowledge, without which we would not have
been able to build toward this accomplishment.

Contents

Preface

Rigid fixation of the facial skeleton has evolved over the past several decades from an avant-garde technique with unacceptably high complication rates to a commonly employed approach offering high rates of success and low morbidities. Patients suffering from facial fractures can be returned to normal function earlier, often avoiding the unpleasant experience of lengthy periods of maxillo-mandibular fixation. The development of better quality, smaller fixation systems has added options for craniofacial fixation after extensive osteotomies, bone grafts, and even simple fractures. This has resulted in greater dependability of the repairs and, therefore, more options from which surgeons can choose for performing extensive mobilization and repositionings of the craniofacial skeleton.

We have been involved in well over a hundred courses and presentations on these topics. This atlas is a response to the frequent requests from course participants and residents for an illustrated volume describing these techniques. We must, of course, acknowledge the tremendous accomplishments of those whose pioneering work has led to the development of rigid fixation techniques for the facial skeleton. The list is far from complete, but we would like to note the superb, innovative achievements of Wilfried Schilli, Bernd Spiessl, Roland Schmoker, Joram Raveh, Berton Rahn, Maxime Champy, Hans-Georg Luhr, Herbert Niederdellmann, and Mostafa Farmand, among many others.

The atlas is designed to provide the reader, from the most experienced surgeon to the operating room technologist, with an easy to understand and even easier to utilize resource. A heavily illustrated chapter on the principles and techniques needed to successfully accomplish fixation of the bones comprising the facial skeleton is included for the less experienced practitioner. The experienced surgeon may wish to see a wide variety of options available for the repair of a particular mandibular fracture, and these are included as well. The contents and index are designed so that a particular repair of a selected injury or osteotomy is easy to locate, and cross references to the necessary surgical approaches and principles are included on the same page.

Recent advances in surgical approaches and in the harvesting and contouring of bone grafts and flaps have evolved during recent years as well. To enhance the usefulness of this atlas, we have elected to include chapters demonstrating the surgical approaches as well as harvesting techniques for bone grafts commonly used to repair craniofacial skeletal injuries and defects.

In preparing this book, we selected an eclectic approach, avoiding adherence to any particular philosophy. Therefore, multiple plating systems and techniques of fixation are represented throughout.

Properly utilized, the techniques of rigid fixation can achieve superior results when repairing facial fractures, osteotomies, and defects. However, the principles and techniques of any particular approach selected must be adhered to exactingly if less than desirable outcomes are to be avoided. It is the our hope that this volume will result in benefits to patients as well as to surgeons, students, and operating room staff. This atlas is intended to supplement formal training, but it is certainly not a substitute for it.

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Acknowledgments

The authors would like to thank Kathey Alexander of Raven Press for making this effort possible and for her assistance and guidance with each difficult step along the road to publication. We also wish to express our sincere appreciation to our secretaries Eve Conti, Michelle Cook, Dawnmaree Girndt, Beverly Bergman, and Julie Gallant, for their many hours of assistance in the preparation of this manuscript.

Of course, this atlas could not have been produced without the excellent artistic contributions of Carmella Clifford, Andrew Grivas, and Michael Leonard. The authors wish to formally thank them for their efforts.

UNIT I

Metallurgy, Instrumentation, and Implants

UNIT OUTLINE

CHAPTER 1

Metallurgy

To be able to use the techniques of rigid fixation, it must be understood and accepted that the implants themselves must be tolerated by the human body, initially and over time. They also must be of a size that is suitable for the intended application, and the strength and malleability must also be suitable. A brief discussion of these aspects will follow.

BIOCOMPATIBILITY

True biocompatibility means that the body's tissues will tolerate the implant material indefinitely, and the material will also remain unaltered (except in the case of bioresorbables) indefinitely in the tissues.

Corrosion

Metals currently used in commercially available plating systems have been shown so far to be markedly corrosion resistant over time when implanted in the human facial skeleton. Initially, as a result of uncertainty, the companies advocated the removal of stainless steel implants to avoid potential corrosion, particularly because some alloys tend to corrode over time. Today, however, after years of experience with implants remaining *in situ*, stainless steel, Vitallium, and titanium implants have all been shown to resist corrosion successfully over time, although some corrosion does occur as evidenced by intracellular deposits. Note also that there are multiple alloys that can be called stainless steel, resulting in greater variability and therefore uncertainty. In recent years, most companies have abandoned stainless steel plates and screws for facial implantation.

NOTE: *An important exception concerns different metals that are in contact, such as a stainless steel screw with a Vitallium or titanium plate or vice versa. The differing galvanic potentials in the tissue environment will lead to galvanic corrosion. It is therefore imperative that implants from different plating sets not be interchanged and mixed (even if they claim to be of the same material, because alloys vary).*

Toxicity/Hypersensitivity

Metal ions are indeed released in small amounts from alloys. Elevations in local tissue concentrations after experimental implantation show these increases to be transient and brief, occurring only during the postoperative period.

Hypersensitivity may occur to metals containing nickel, cobalt, and chromium when these are implanted in large volumes, such as in hip prostheses. This is apparently not a problem with the facial implants currently available commercially. Of the metals used, only pure titanium has never elicited a human hypersensitivity reaction.

Carcinogenicity

Some questions have been raised regarding the potential for carcinogenicity of metal implants, particularly for those containing high amounts of nickel, although a cobalt—chromium alloy (Vitallium) has also been questioned. The incidence rate is so small, however, that no direct cause-and-effect relationship can be proved. No suspicions related to pure titanium have arisen thus far.

Osseointegration

The term osseointegration implies the development of a biological bond between the metal implant and the surrounding bone. Osteocytes grow up to and adhere to the metal surface, without any intervening fibrous tissue layer. Although this occurs inconsistently, it appears to occur only with pure titanium implants and, even then, only when meticulous technique has been used.

Of course, osseointegration is not required for the repair of facial fractures and osteotomies. However, it has been suggested that the propensity for pure titanium to osseointegrate implies its better biological reception by bone tissue. This is critical in certain situations, such as in the placement of permanent dental implants. Note that this feature has been used to advantage in the titanium hollow screw reconstruction plate system (THRP).

METALS

Stainless Steel

Except for the Champy miniplating system (Martin), most commercial plating companies have abandoned stainless steel

as the component of facial plating systems. Although strong and malleable, the fear of corrosion and potential toxicity led most manufacturers who previously used stainless steel to convert to titanium.

Vitallium

This is a trade name for a cobalt, chromium, and molybdenum alloy used by the Howmedica Company in the Luhr facial plating systems. Its tensile strength is greater than that of titanium, and it is biocompatible, although osseointegration has not been found. Its greater tensile strength allows implants for similar applications to be thinner than titanium implants.

Titanium

Pure titanium exhibits the best corrosion resistance and biocompatibility. It also has the lowest modulus of elasticity among the three commonly used metals. However, although much lower than that of steel or Vitallium, it is still significantly greater than that of bone. In comparison with the other metals, titanium also offers the least interference with magnetic resonance imaging and CT scans.

Bioresorbables

Attempts to use bioresorbable materials, such as the various polyesters used in resorbable sutures, for the fixation of bones date back at least three decades. Despite the testing and successful utilization of a wide variety of these materials (e.g., polylactic acid, polyglycolic acid, and polyparadiaxanone) in animals and in humans, complication rates continue to be unacceptably high. As of the time of this writing, there is no commercially available bioresorbable facial plating system in the United States that utilizes these materials.

CHAPTER 2

Instrumentation

There are numerous companies that manufacture systems for the rigid fixation of the facial skeleton. It would be impossible to be all inclusive in this section. The purpose of this portion of the atlas is to introduce the reader to a variety of the materials that might be encountered in the operating room. The instruments of several companies are represented in the text and accompanying photographs. Particular instruments may or may not be available at the time when this text is read because instruments and companies change in this field at an incredible rate.

This section is organized to demonstrate some of various instruments available. The text identifies the instruments shown, and when the mechanism of use may not be entirely obvious to all readers, this is also explained.

REDUCTION FORCEPS

Reduction forceps are designed both to help the surgeon manipulate the bone fragments into satisfactory reduction and to maintain the reduction after it has been achieved. Various types of reduction forceps are used in practice.

Towel Clip-Type Bone-Holding Forceps

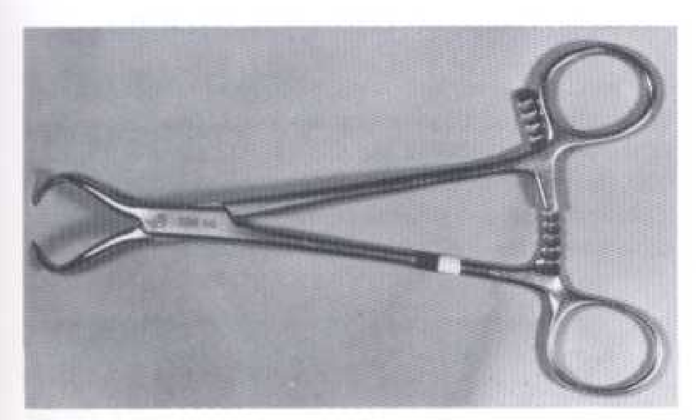


FIG. 1-1

The towel clip type of bone-holding forceps is essentially a modified towel clip, with extra clicks on the locking mechanism. This can be used to hold large abutting segments of bone together,

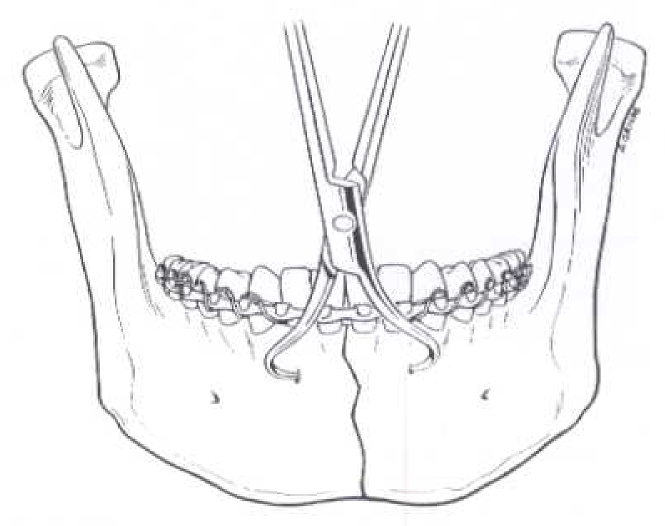


FIG. 1-2

and it may be used to hold overlapping bone fragments together in preparation for lag screw fixation.

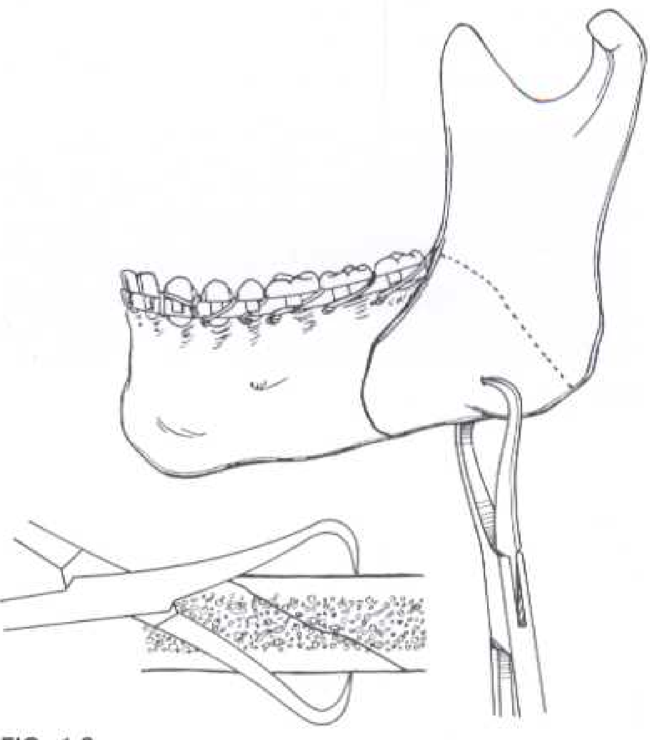


FIG. 1-3

Bone-Holding Clamps

Various bone-holding clamps are used to grasp and hold pieces of bone for manipulation and stabilization. These are designed to minimize crushing, which could lead to fragmentation or other bone damage.

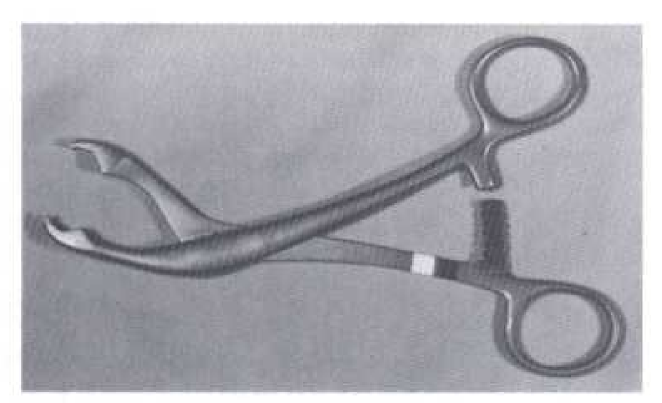


FIG. 1-4

Reduction/Compression Pliers

The mandibular reduction/compression pliers (forceps) are designed specifically for stabilization and precompression of mandibular fractures in preparation for compression plating. These are designed so that hollow sleeves can be screwed into the inferior border of the mandible from below. The holes for these are drilled approximately parallel to the fracture line, and the screws should be no longer than 8 or 10 mm to avoid injury to the inferior alveolar nerve. They should not be tightened firmly to allow ease of placement of the pliers.

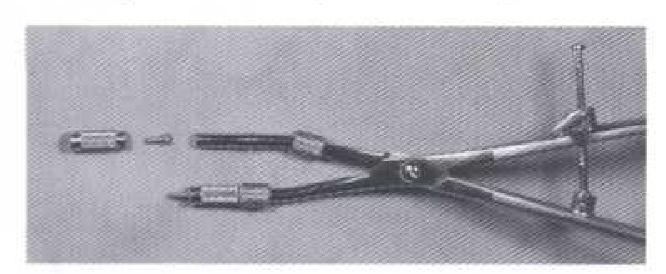


FIG. 1-5

The pliers are then attached to the sleeves by slipping them into the hollow sleeves and finger tightening the nuts. The pliers can then be used to manipulate the fragments into reduction. Once reduced, they can be precompressed, and the position is held by tightening the lock nut on the handle of the pliers.

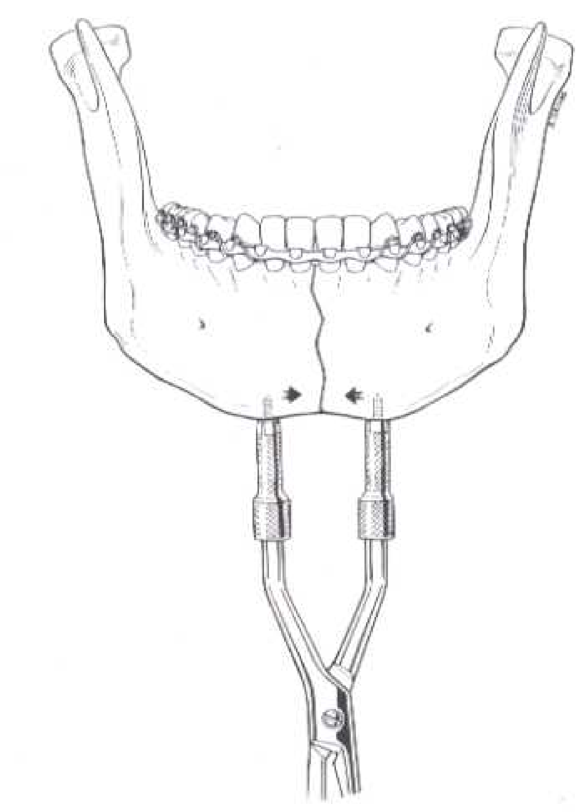


FIG. 1-6

Reduction/Compression Pliers With Side Rollers

The reduction/compression pliers (forceps) with side rollers are a variation of the pliers just described. These are applied to the inferior border of the mandible as described earlier. The sleeves, however, have side rollers attached to them. These are used to compress the alveolar border of the mandible when a tension band cannot be placed.

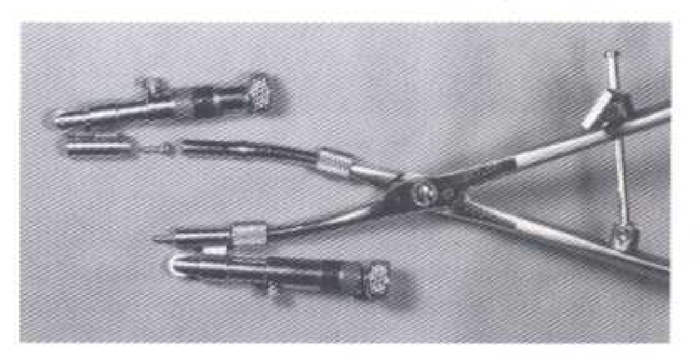


FIG. 1-7

Compression of the inferior border initially will distract the alveolar border.

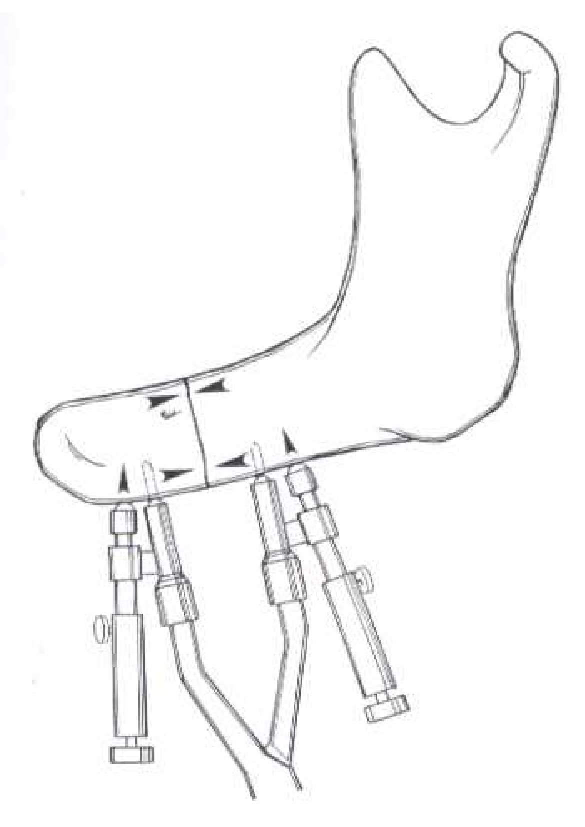


FIG. 1-8

After horizontal compression has been applied, the side rollers are tightened against the inferior border of the mandible on either side of the sleeves. This forces the alveolar border of the fracture to be compressed.

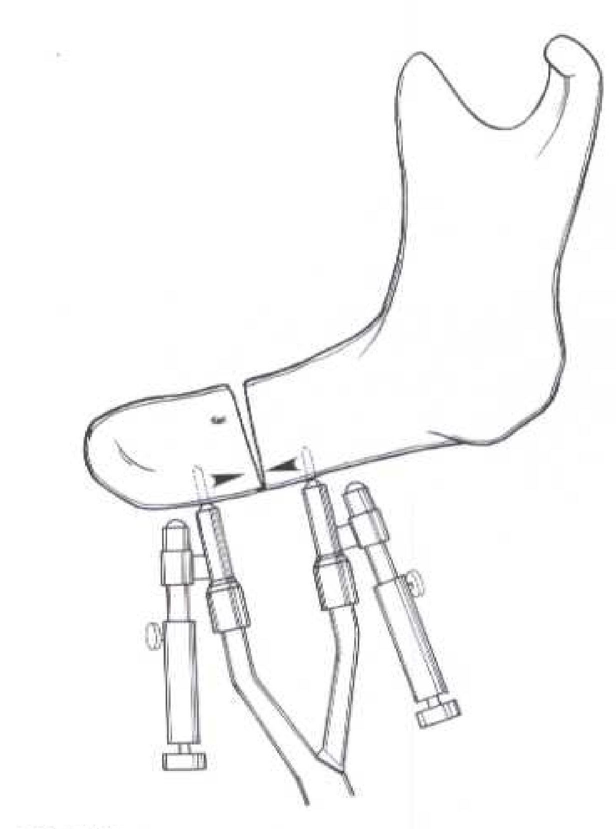


FIG. 1-9

PLATE-HOLDING FORCEPS

A plate-holding forceps can be any device that is used to hold a plate in place on the bone in preparation for screw application. The forceps shown here is like a modified towel clip, except that one prong has been made into a solid piece of metal for insertion into a plate hole. The pointed prong holds into the bone from underneath.

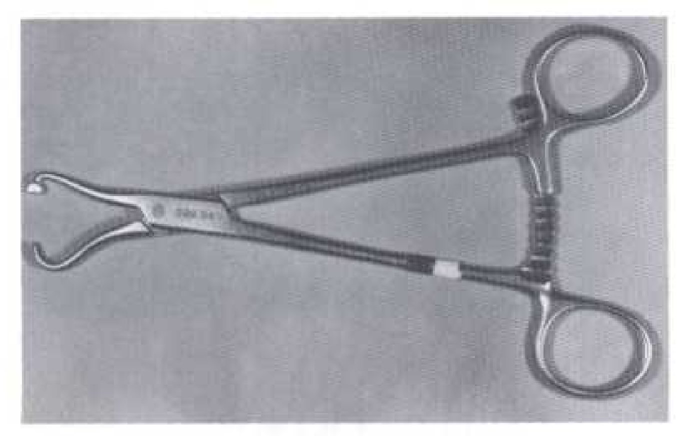


FIG. 1-10

Another type of plate-holding forceps is like a clamp with a slot designed to fit a specific size plate. The plate-holding forceps shown here are from the Luhr system.

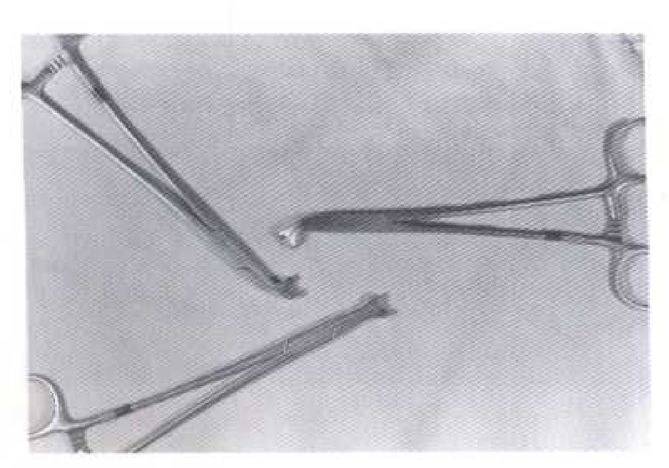


FIG. 1-11

The Storz system uses a slotted rod that has a slot that grips the plate snugly. After the plate has been screwed to the bone, the rod is lifted off the plate.

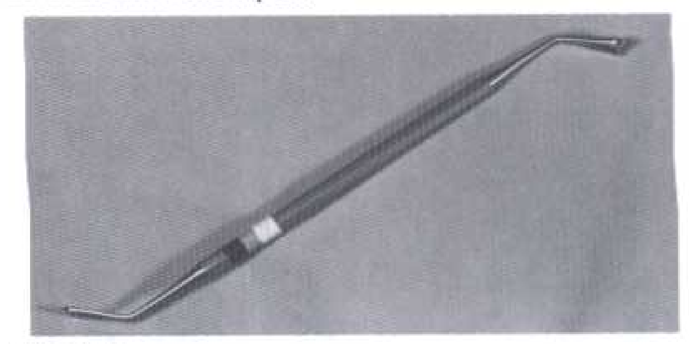


FIG. 1-12

SCREW-HOLDING FORCEPS

Most screwdrivers are designed with sleeves that will hold the screws for placement.

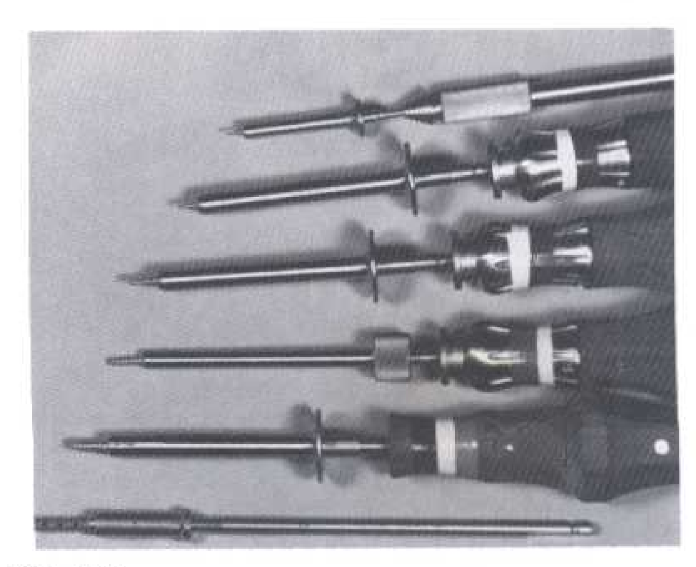


FIG. 1-13

As an alternative, the Luhr system contains clamps with round openings at the ends that are designed to grasp and hold a screw by its shaft just below the head. The screw is held in place until it catches in the bone, and then the clamp is released.

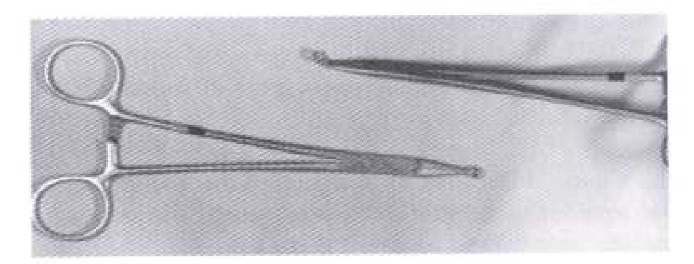


FIG. 1-14

PLATE BENDERS

Plate benders come in a variety of shapes and sizes. Therefore, they can be used for bending a variety of different size plates and for bending them in a variety of directions.

Bending Irons

Various bending irons are depicted here. They come in different sizes and are able to bend plates of different sizes. Notice the slots in these irons are designed to grab the plate in different areas, and then by holding one iron in each hand, the plate can be bent or twisted into the appropriate shape.



FIG. 1-15A

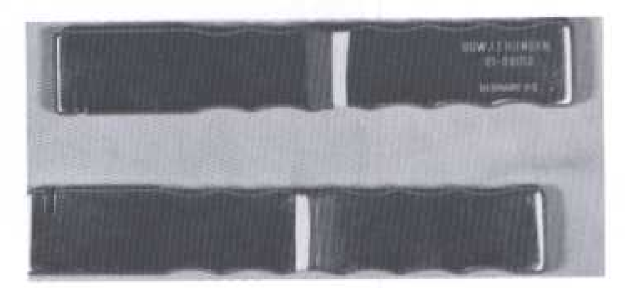
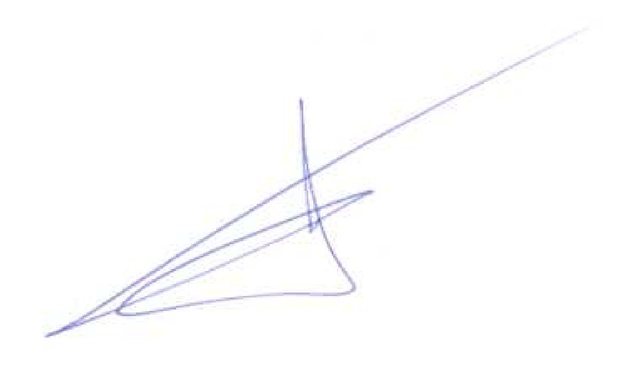


FIG. 1-15B



Bending Pliers

Like bending irons, bending pliers come in various sizes and types.

Flat Pliers Flat pliers are designed so that the user can grab a portion of the plate with pliers in each hand and then bend the plate to the appropriate desired shape.

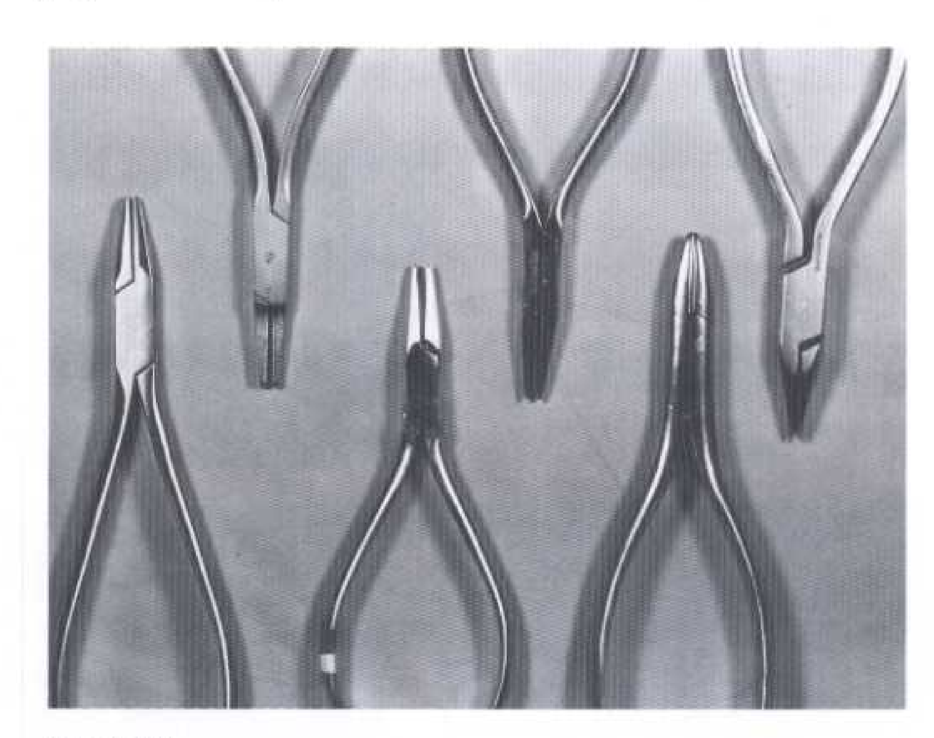


FIG. 1-16A

Some will bend the flat surface of the plate around a raised central portion of the pliers.

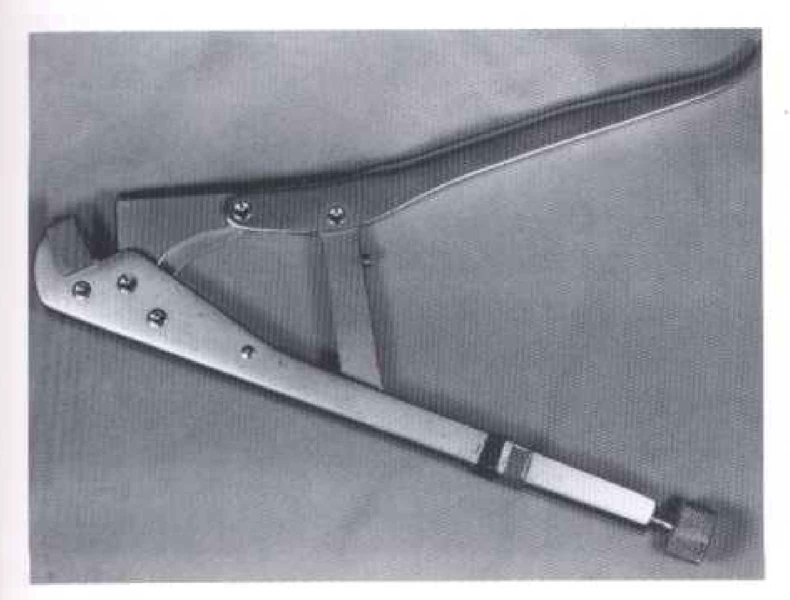


FIG. 1-16B

Pronged Pliers Pronged pliers are designed specifically so that the plate can be placed so that the flat portion of the plate lines up with the prongs or so that the prongs actually go into the holes of the plate. Squeezing the pliers will cause the plate to bend in a curve along its side, and the two holes end up above or below the single hole where the single prong is.

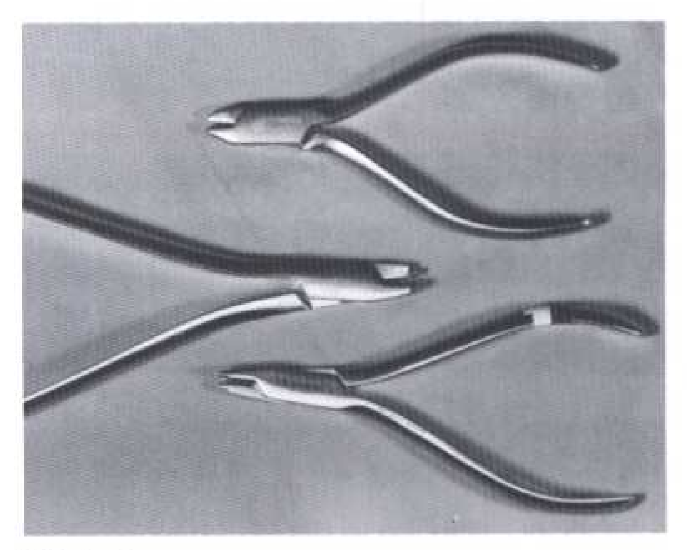


FIG. 1-17

Side-Bending Pliers Side-bending pliers are designed so that the plate can be placed flat along the side of the pliers, and squeezing the handles (similar to the pronged pliers) will result in a bend in the plate between the holes rather than along the flat surface. This type of bend is necessary in some situations, such as rounding the angle of the mandible.

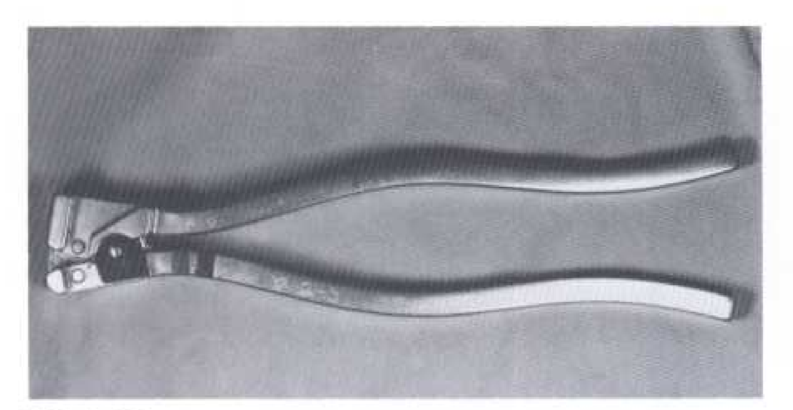


FIG. 1-18A

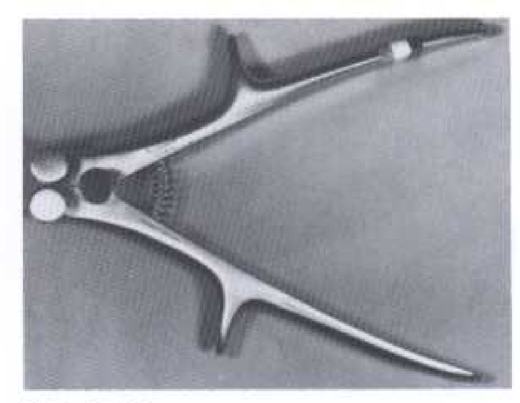


FIG. 1-18B

AO 2.7-mm Reconstruction Plate Benders These benders are specifically designed to grasp the AO 2.7-mm reconstruction plate by grabbing the plate with a prong in a plate hole. Two pliers are used so that, with one in each hand, the plate can be bent or twisted. Note that the disadvantage of this particular type of pliers is that it tends to create distortions in the plate hole region of the plate. This makes the plate more difficult to use, and it also weakens it.

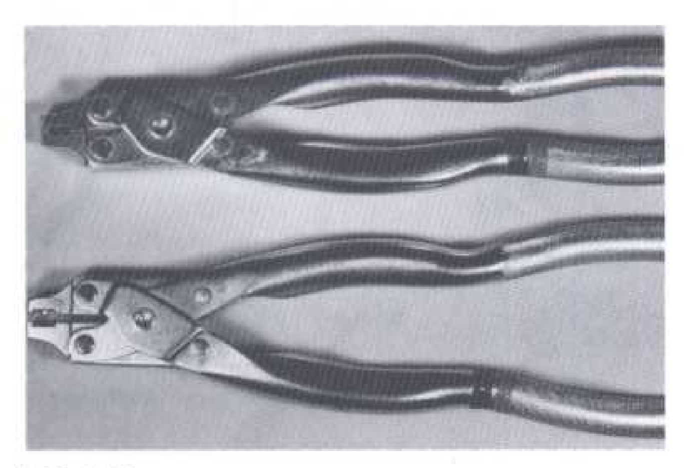


FIG. 1-19

PLATE CUTTERS

A plate cutter, of course, can be any instrument that is able to cut a plate to the desired length. Obviously, if the plate is longer than is needed for the specific indication, it can be cut to length. Small cutters are used for small plates.

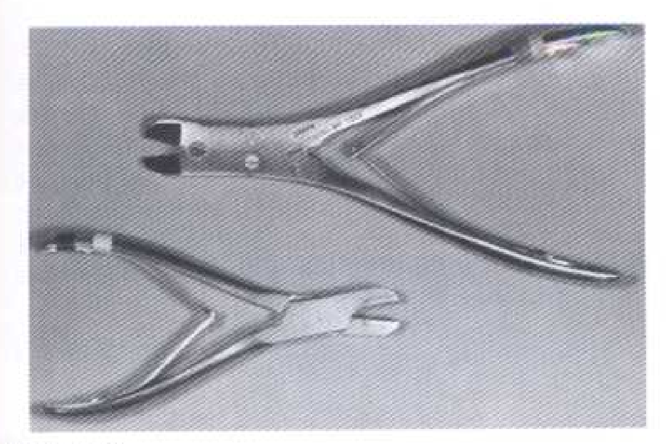


FIG. 1-20

Larger cutters, such as Steinman pin cutters, can be used to cut larger plates.

TEMPLATES

Templates are basically thin pieces of metal that are easily bendable and are made in sizes and shapes to match the particular plates to be used. Most sets contain templates that match the various plates in the particular set. Templates are generally bent right onto the bone, being malleable enough to be pushed into shape with a finger or instrument. They are then carefully lifted from the wound and used as a template for bending the actual implant. It is important to keep in mind that the templates are very weak, and they should not be inadvertently implanted instead of a plate.

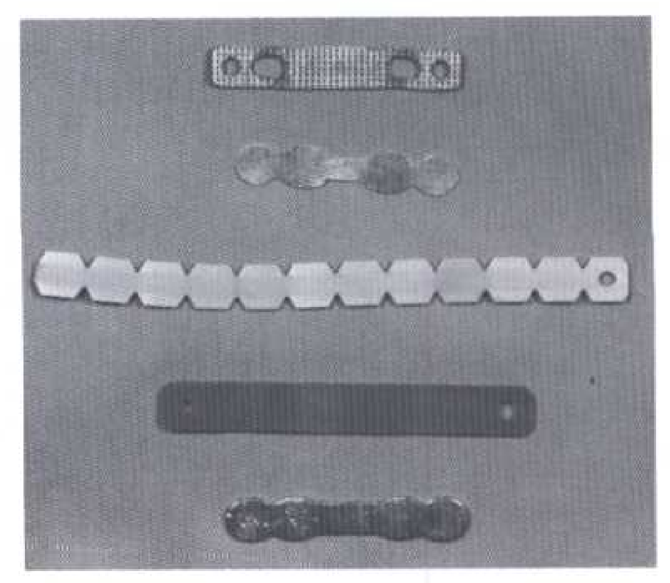


FIG. 1-21

DRILLS

As would be anticipated, drills come in the various sizes needed for the particular screw to be implanted. Keep in mind that, as a general rule, the drill bit to be used for any threaded hole is the size of the shaft of the screw. Therefore, the hole that will be bored in the bone will be the size of the screw shaft. The screw thread is, of course, larger than the screw shaft, and this will then extend into the bone surrounding the hole that has been drilled. Note that, for the placement of a lag screw, the first bony cortex is drilled with a gliding hole that will not catch the screw thread; it is, therefore, the size of the screw thread rather than the screw shaft.

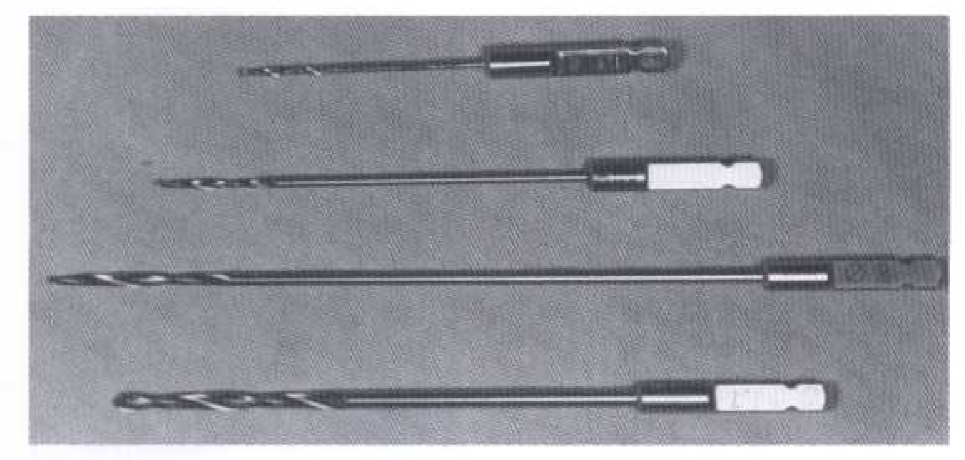


FIG. 1-22A

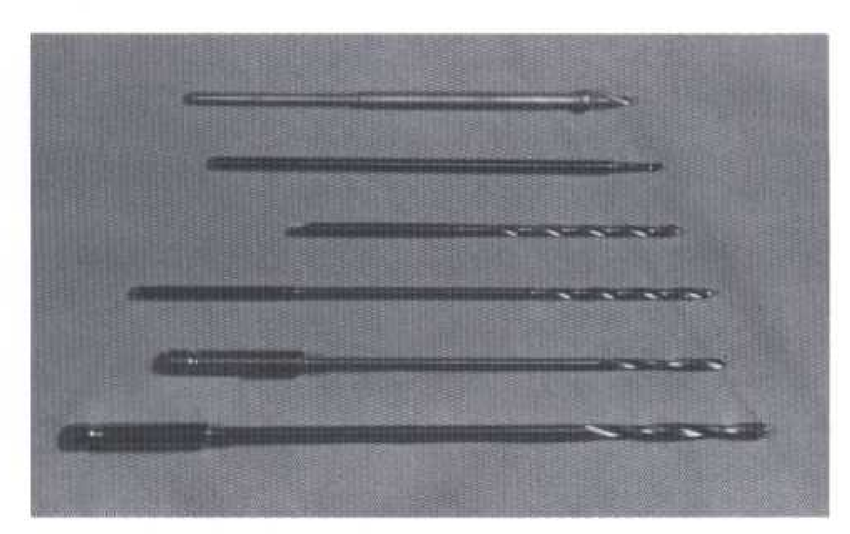


FIG. 1-22B

(As a general rule, 1.0-mm screws are placed by using a drill that is 0.6 to 0.8 mm in diameter; 1.2-mm screws, by using a drill bit that is 1.0 mm in diameter; 1.5-mm screws, by using a drill bit that is 1.1 mm in diameter; 1.7-mm screws, by using a drill bit that is 1.3 mm in diameter; 2.0-mm screws, generally, by using a drill bit that is 1.5 mm in diameter; 2.4-mm screws, generally, by using a drill bit that is 1.8 mm in diameter; 2.7-mm screws, generally, by using a drill bit that is 2.0 mm in diameter; 3.5-mm screws, generally, by using a drill bit that is 2.7 mm in diameter; and 4-mm screws, generally, by using a drill bit that is 3.0 mm in diameter.) Note that some drill bits have stops on them so that the hole can only be drilled to a certain depth. These are helpful when drilling monocortical holes for miniplate fixation of the mandible to decrease the likelihood of deep penetration into a tooth root or the inferior alveolar nerve.

DRILL GUIDES

A proper drill guide is not a tissue protector as much as it is designed to hold the distal shaft of the drill in a straight position, preventing wobble while the drill bit cuts the bone. This will minimize the possibility of creating a funnel-shaped hole. It is, therefore, important that the drill guide match the size of the drill bit. It should not be several sizes larger because that would defeat its purpose.

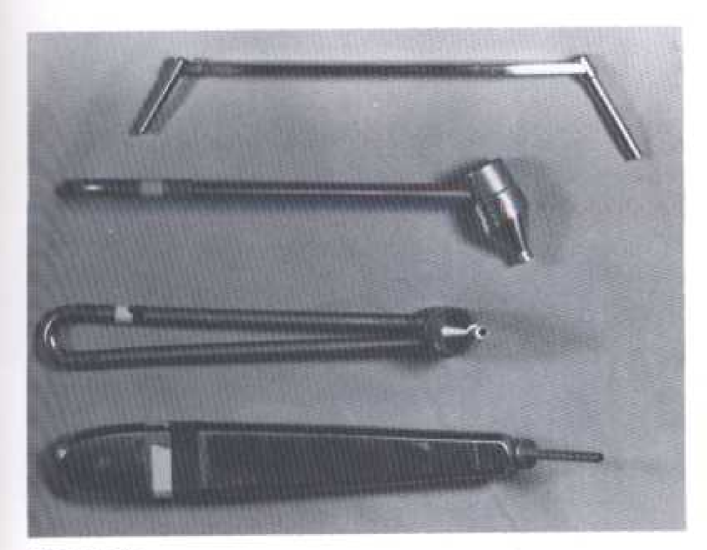


FIG. 1-23

Neutral

Some drill guides are designed so that they fit only neutrally in the hole. For example, in an oblong, elliptical hole, a drill guide that has a similar oblong, elliptical shape with a hole in its center will only allow drilling of the hole in the center. This will provide a neutral hole, avoiding any compression forces.



FIG. 1-24

Eccentric

Some drill guides are designed to make certain that the hole is drilled eccentrically in an elliptical hole to facilitate compression. These have a shape that is similar to the shape of the plate hole, and they position the screw eccentrically within the guide. It is important to make certain that the guide is positioned so that the screw will be at the appropriate end of the hole, i.e., positioned eccentrically away from the area where the forces of compression are directed. Note that some drill guides are designed for elliptical holes so that they can be used either as neutral or compression guides. In this case, by directing the drill guide in the right direction and pulling it to the end of the plate hole, the drill hole is positioned. Great care must be taken in using these guides properly.

DEPTH GAUGES

A depth gauge is a device that is designed to measure the depth of the hole. The depth gauge is placed after the hole is drilled. When a system that requires tapping is used, the depth is always measured prior to tapping so that the depth gauge does not damage the thread that has been cut by the tap in the bone. The depth gauge has a lip on the end that is used to catch the undersurface of the bone; then the portion with the gauge is brought down to the surface of the bone. An indicator on the gauge will show the depth of the hole. Note that, when the measure falls between two sizes, as a general rule, the longer screw is used. This is particularly important when bicortical screws are being placed. However, in other situations, the use of the shorter length may be preferable at the discretion of the surgeon.

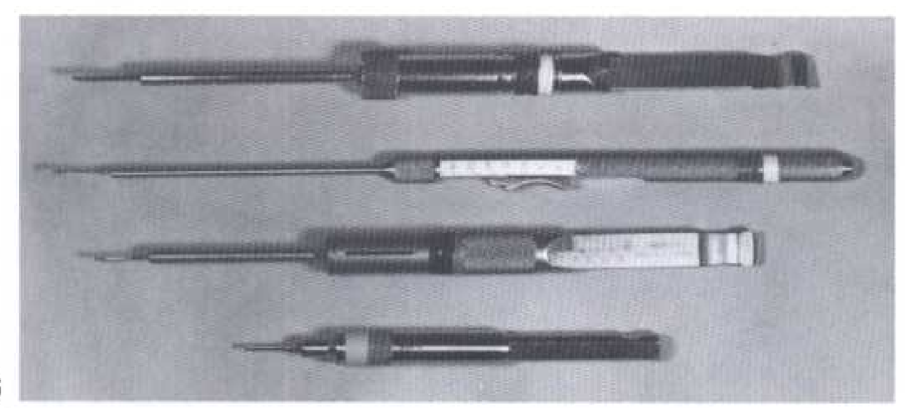


FIG. 1-25

TAPS

A tap is simply a device that is designed to cut the thread in the bone prior to the placement of the screw. The tap for any particular screw must be the appropriate one for that screw so that the threads match precisely. It is, therefore, critical that the appropriate-sized tap from the appropriate set by the appropriate manufacturer always be used. Note that taps, like self-tapping screws, are fluted to permit bone debris created by cutting the thread to escape. This avoids the compression of the dust in the threads, which may result in microfracture of the threads.

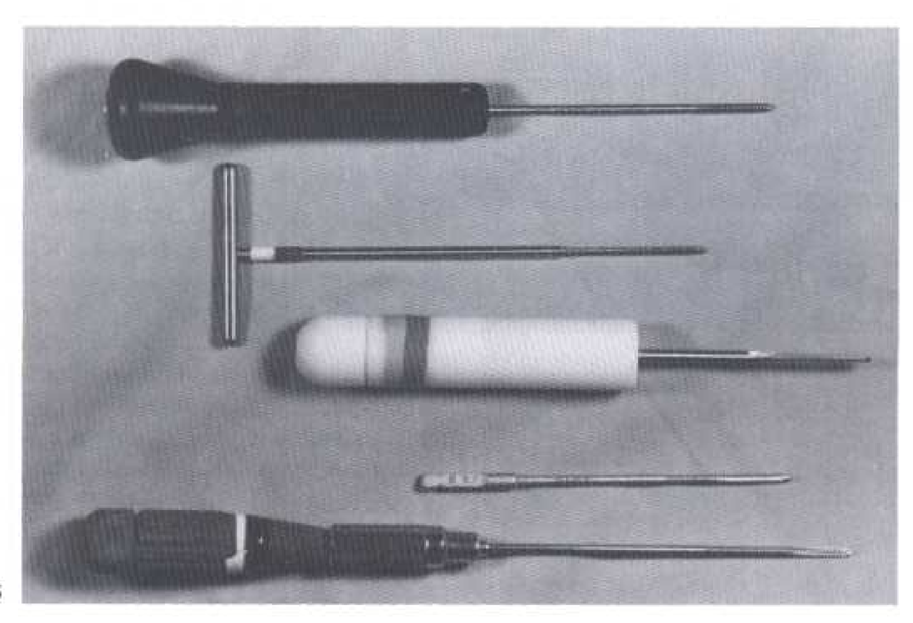


FIG. 1-26

SCREWDRIVERS

Like taps, screwdrivers are designed specifically to match the particular screws that are being inserted. Note that there are a variety of different screw head designs, necessitating a variety of screwdriver designs. Some screws are Phillip's head (Howmedica), some are hexagonal head (Storz 2.7 mm and Synthes 2.7 mm), and some have cruciate or cross-slotted heads (which are typical of most mini- and microscrews).



FIG. 1-27A

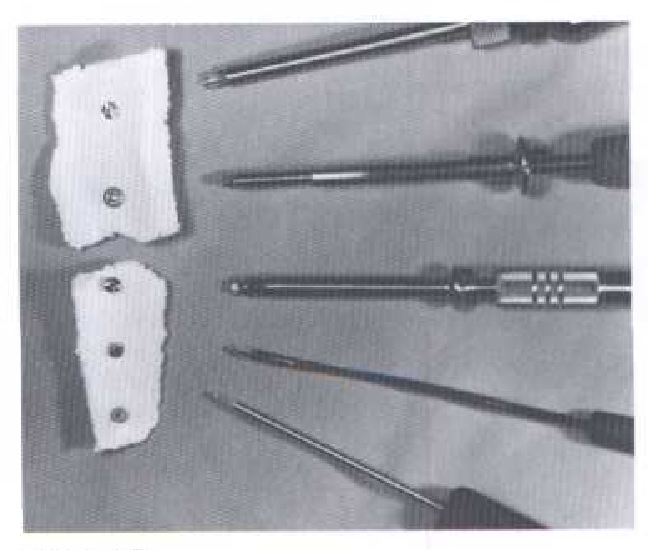


FIG. 1-27B



Note that screw drivers come with and without devices that are designed to hold the screw in position on the screw driver.

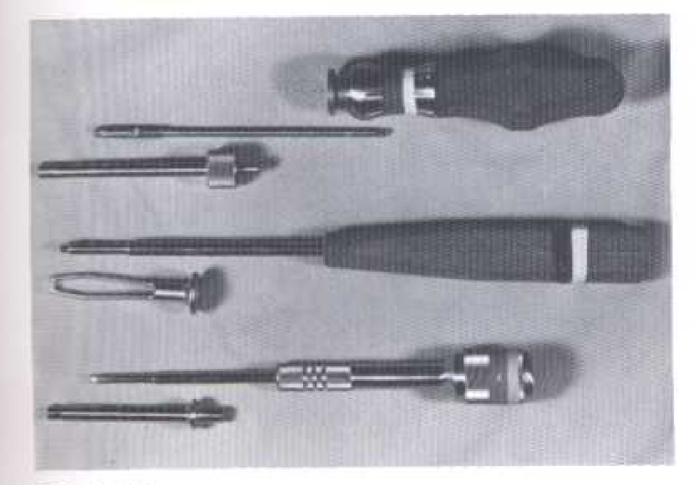


FIG. 1-27C

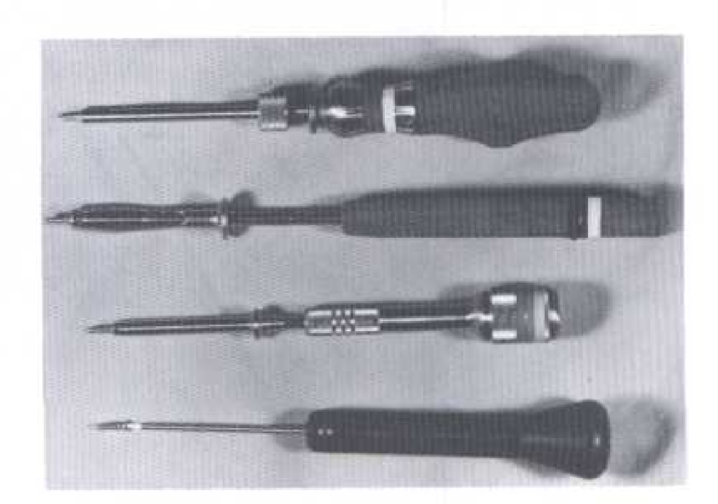


FIG. 1-27D

TISSUE PROTECTOR SLEEVES

A tissue protector sleeve is designed to protect the tissue during placement of a screw or tapping of a hole. Note that this is different from a drill guide because the tissue protector is generally designed with play around the device. Thus, it does not prevent wobble. It is merely designed to keep tissue from getting into the hole or into the threads of the instrument.

TRANSBUCCAL INSTRUMENTATION

Each system has its own version of transbuccal instrumentation. In general, these are tissue protecting-type devices on a handle that can be passed through the cheek from extraoral to intraoral, and they are then used for all steps in screw application, including drilling, measuring, tapping (when needed), and screw placement. Some transbuccal instruments, such as the Synthes and the Leibinger, include cheek retractors as part of their design.

Trochars

The trochar is a pointed instrument that fills the sleeve of the transbuccal device. It is designed with a point that is tapered to push tissue aside as the instrument is passed through the cheek.

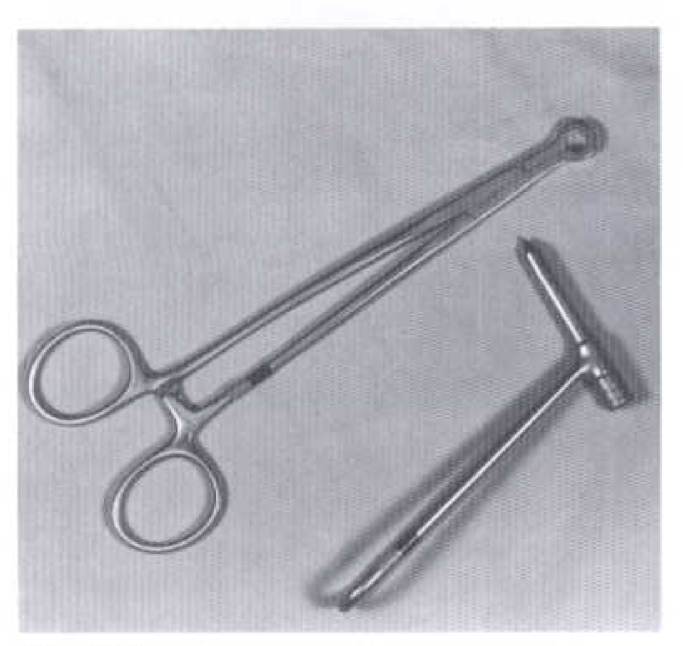


FIG. 1-28A

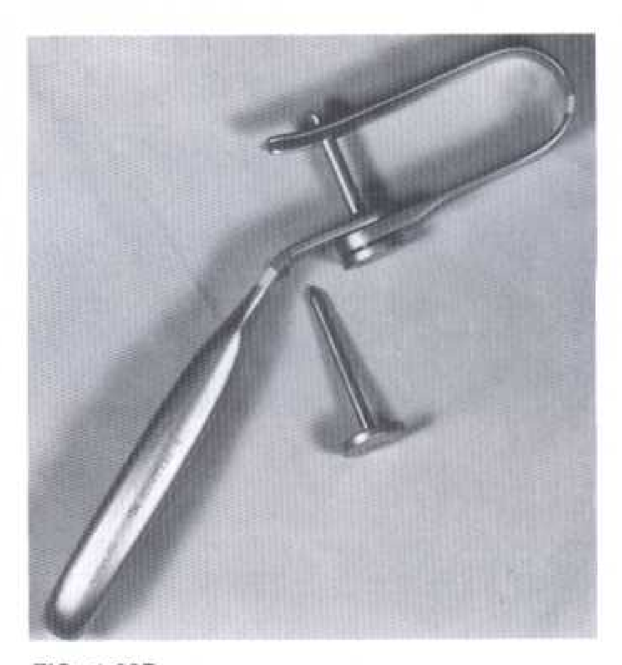


FIG. 1-28B

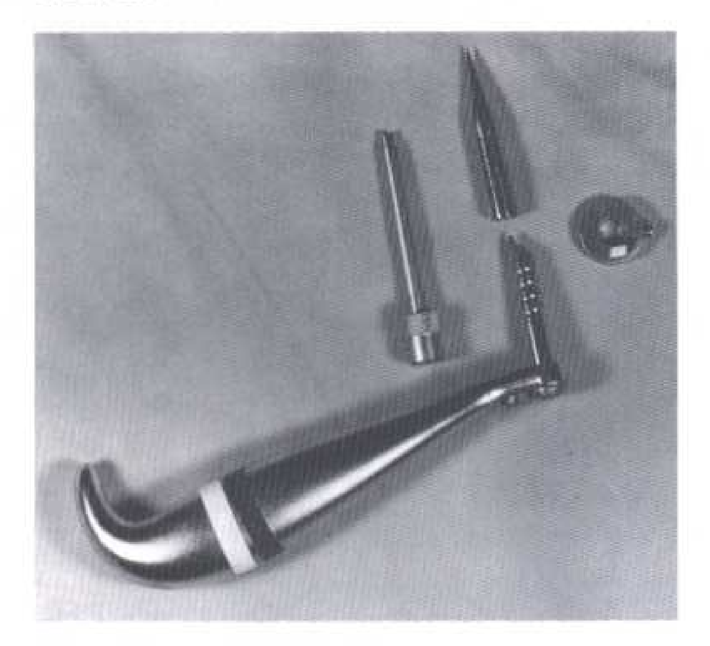


FIG. 1-28C

Guides

These are generally sleeves that slip within the instrument after placement, and they are designed specifically to match the size of drill bits, thereby serving as drill guides during drilling. Some have hooks on the end that will help align them with the plate or catch the plate hole. Others are smooth.

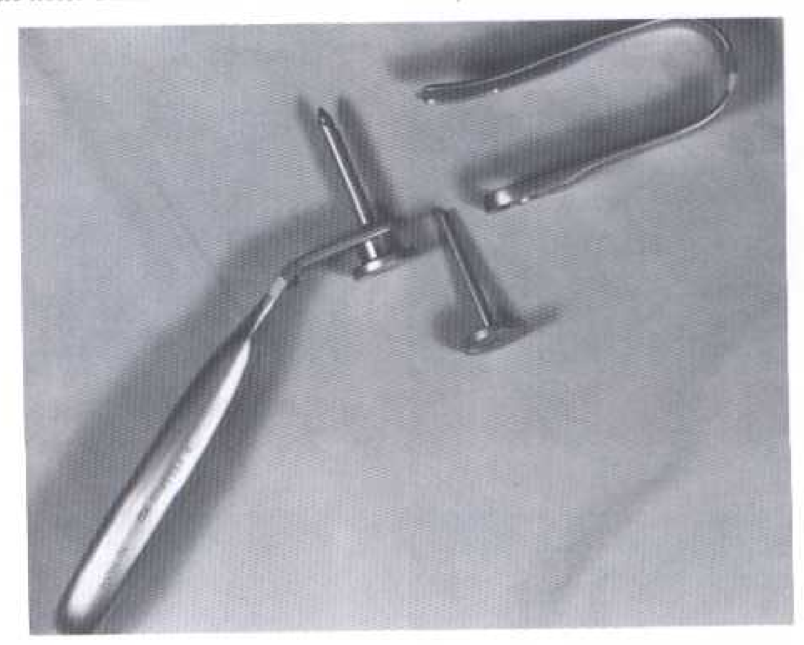


FIG. 1-29A

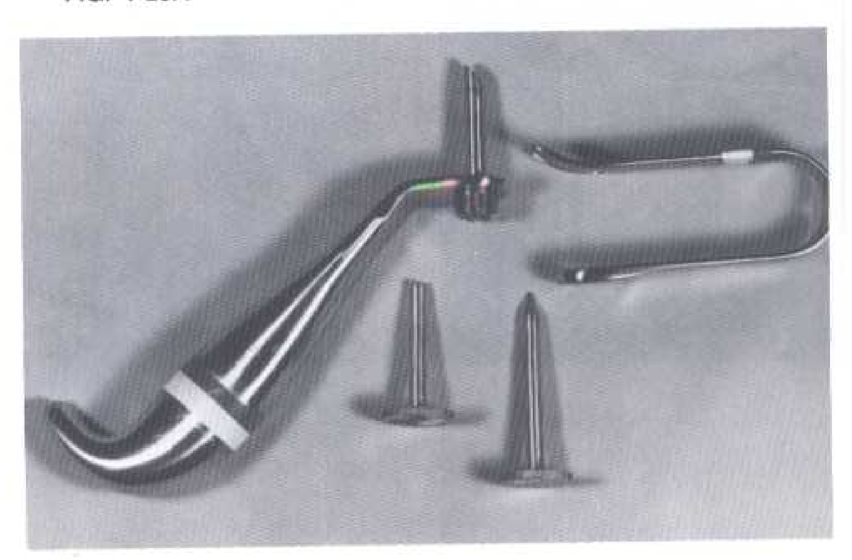


FIG. 1-29B

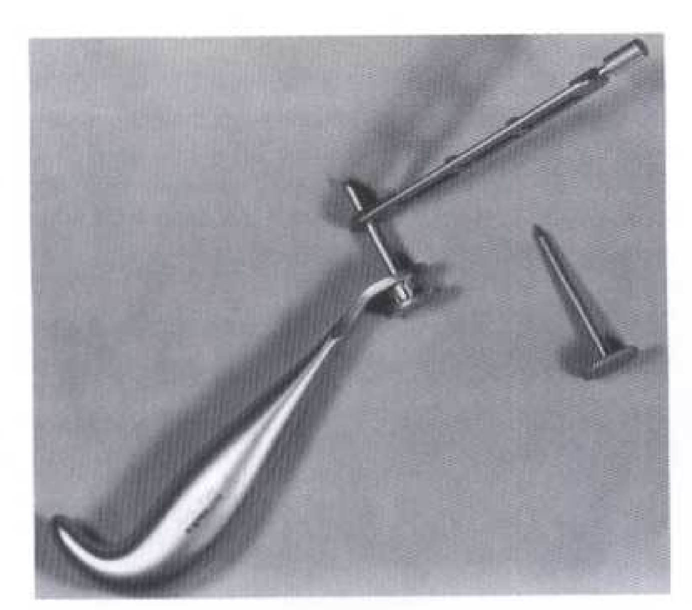


FIG. 1-30A

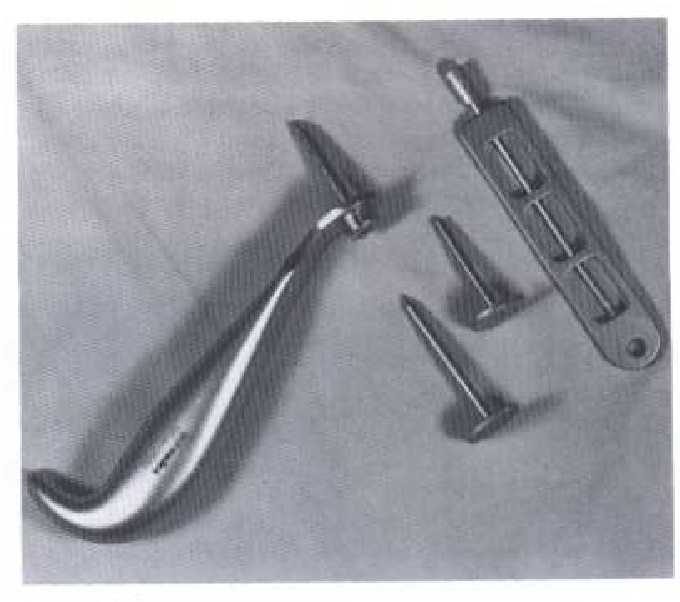


FIG. 1-30B

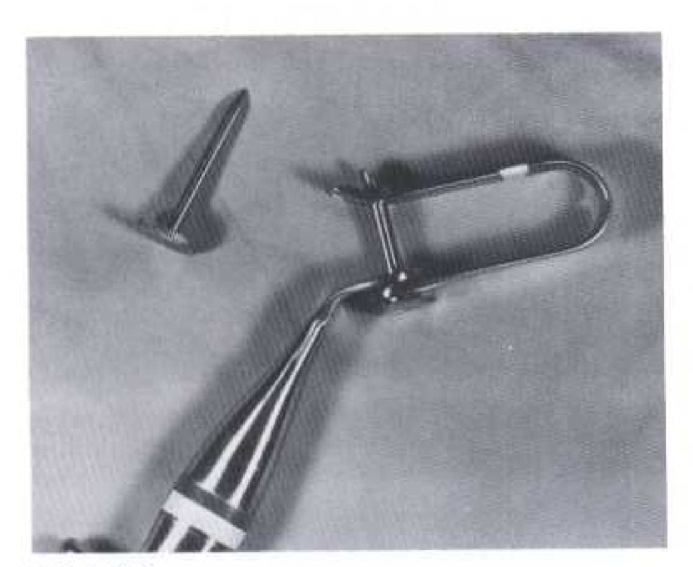


FIG. 1-30C

Retractors

Shown in the diagram are the retractors from the Techmedica and the Leibinger sets. These are designed to pull the cheek out of the way for visualization of the bone intraorally. Note that the Techmedica device (Figs. 1-30A and B) requires tightening of the little screw against the transbuccal sleeve, which can result in bending of the sleeve and later problems passing the drill guide. The Leibinger retractor is slotted to allow it to be positioned in various directions relative to the handle and held in place.



FIG. 1-31A

In the Luhr version, the intraoral clamp in fact is exactly that. It is a clamp that is designed to fit around the end of the sleeve and clamp down on it.



FIG. 1-31B

THRP-RELATED INSTRUMENTS

The THRP system is a unique self-contained system designed for placement of, not only hollow screws, but also screws that have expandable heads. Therefore, they are ultimately fixed tightly to the plate itself after they have been fixed to the bone. Two systems exist with a slight difference between them. In the so-called THRP-2, produced by Leibinger, the plate holes have been reinforced, obviating the need for the placement of inserts during bending.



FIG. 1-32

Unique instruments for this set include:

1. Inserts that are placed in the plate holes during bending (required only in the Synthes system). These maintain the shape of the plate holes so that they are not distorted during the bending process.

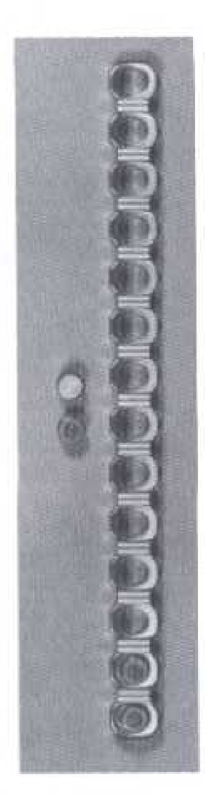


FIG. 1-33

2. A device to punch the inserts out of the holes after the bending process is complete (similarly used only with the Synthes system).

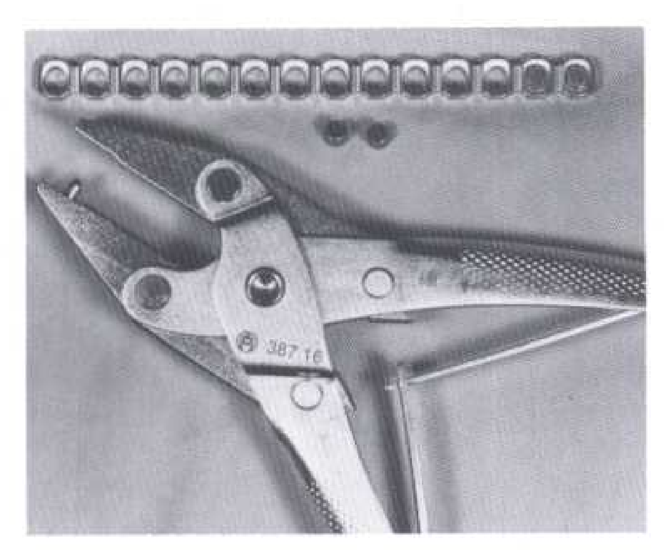


FIG. 1-34

3. A reamer that is designed to make certain that the plate holes are round and adequate so that the expandable heads will fit comfortably in them.

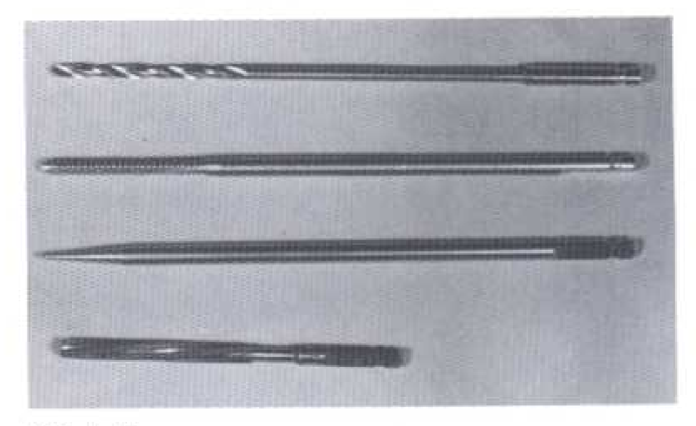


FIG. 1-35

4. Hollow screws with expandable heads.

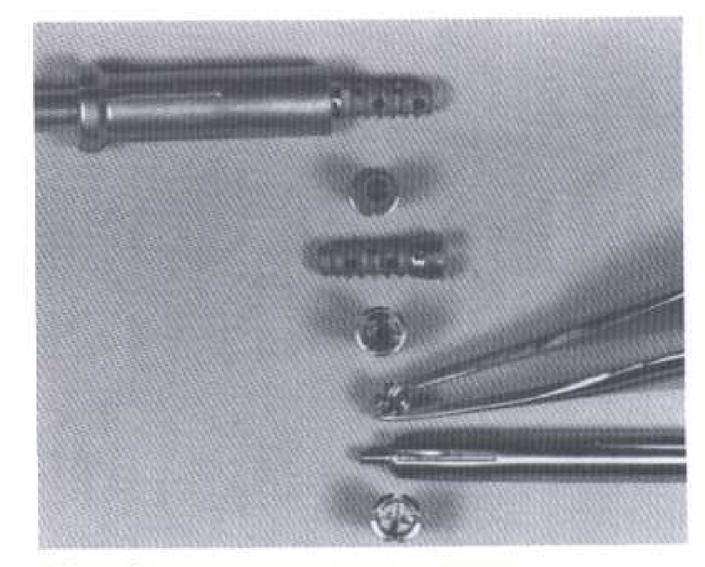


FIG. 1-36

5. Expansion bolts, which are small insert screws that actually screw into the heads of the screws after they have been placed and tightened. These expand the heads of the screws and thereby fix them firmly to the plate.

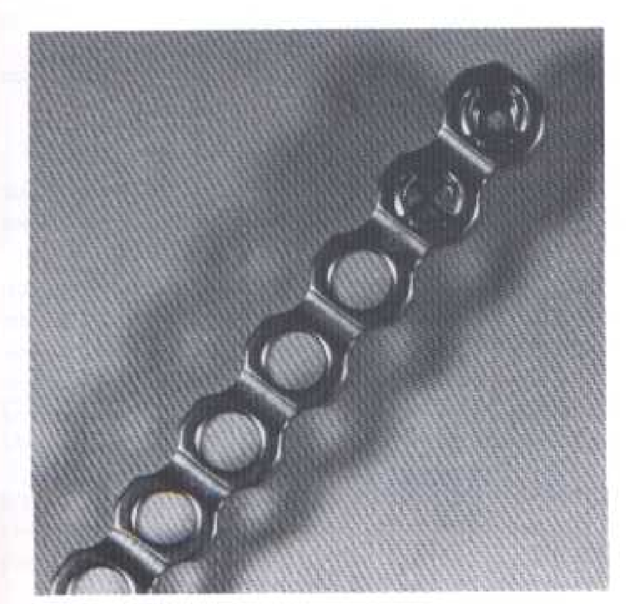


FIG. 1-37A

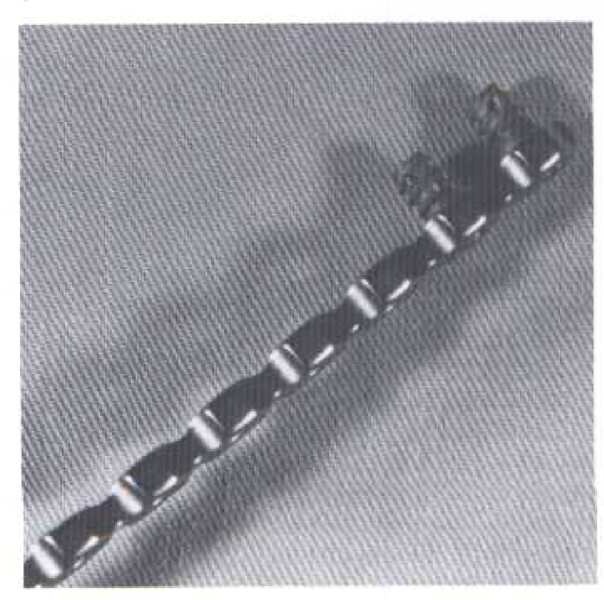


FIG. 1-37B

CHAPTER 3

Implants

Implants include plates, screws, and temporomandibular joint prostheses. The plates and screws are made of a variety of metals, depending on the manufacturer's preference. The Champy system is made of stainless steel; the Luhr system is made of Vitallium; the Storz system, most Synthes systems, and the majority of Leibinger systems are made of titanium; and the Lorenz system is made of a titanium alloy. (Metallurgy was discussed earlier.) Of great importance, however, is to be certain not to mix metals. It is critical to use plates and screws made of the same metal to avoid ionic interactions that will lead to corrosion and, possibly, the development of toxins. Therefore, screws from one set should never be mixed with plates from another, even if they are made by the same manufacturer.

PLATES

This section is divided primarily by indication, although sizes vary, even within an indication. For easy reference, these are divided into mandibular reconstruction plates, mandibular compression plates, mandibular miniplates, midfacial miniplates, and microplates.

Note that plates can be designed as compression plates, which can be used to produce compression across a fracture, depending on the screw placement (see Unit 2, *Placing a Compression Plate and Screws*, for further explanation and clarification), or they can be designed as neutral plates, which can be used only in a neutral fashion. Neutral plates have only circular holes; they cannot be used to create compression.

Mandibular Reconstruction Plates

A mandibular reconstruction plate is a plate that is designed to be long enough and strong enough to bridge defective or functionally defective areas of the mandible, such as areas of severe comminution or atrophy of the bone. Proper utilization of these plates requires that at least three or four screws be placed into healthy bone on either side of a defective area.

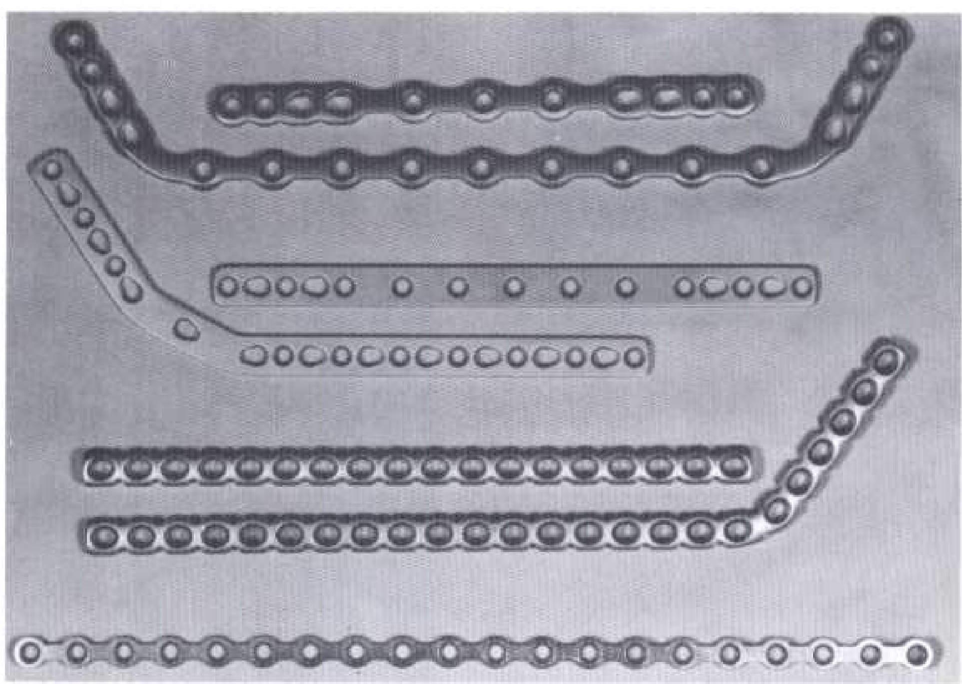


FIG. 1-38

Standard Standard mandibular reconstruction plates come in various shapes and sizes, depending on the manufacturer's preference. Most use 2.7-mm screws, although a smaller version of mandibular reconstruction plate made by Synthes uses a 2.4-mm screw. As in the earlier examples, some have all elliptical holes, such as the Synthes type, which can be used either to apply compression or place neutral screws. Some have both neutral (only circular) holes and elliptically designed holes so that some holes can be used to apply compression, such as the Luhr plate. Some can be used only for neutral screw placement.

THRP This is a unique plate design (described earlier). The holes in this plate, of necessity, are round to fit the expandable screw heads; therefore, only neutral placement is possible. The unique aspects of this plate, as noted previously, are the hollow screw design (which is an optional component because either hollow or solid screws can be used) and the expansion bolt, which is screwed into the head of the screw after the plate has been placed. This expands the screw head and fixes it firmly to the plate itself. This provides the additional benefit of maintaining the screw immobile if there is resorption of the bone around the screw thread for any reason.

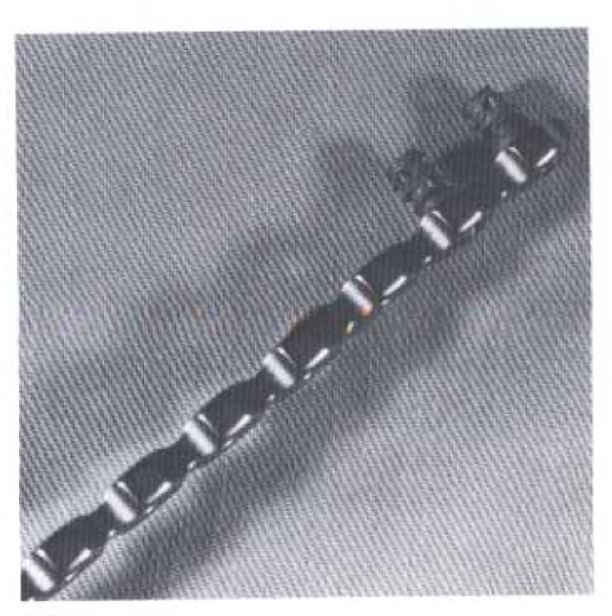


FIG. 1-39

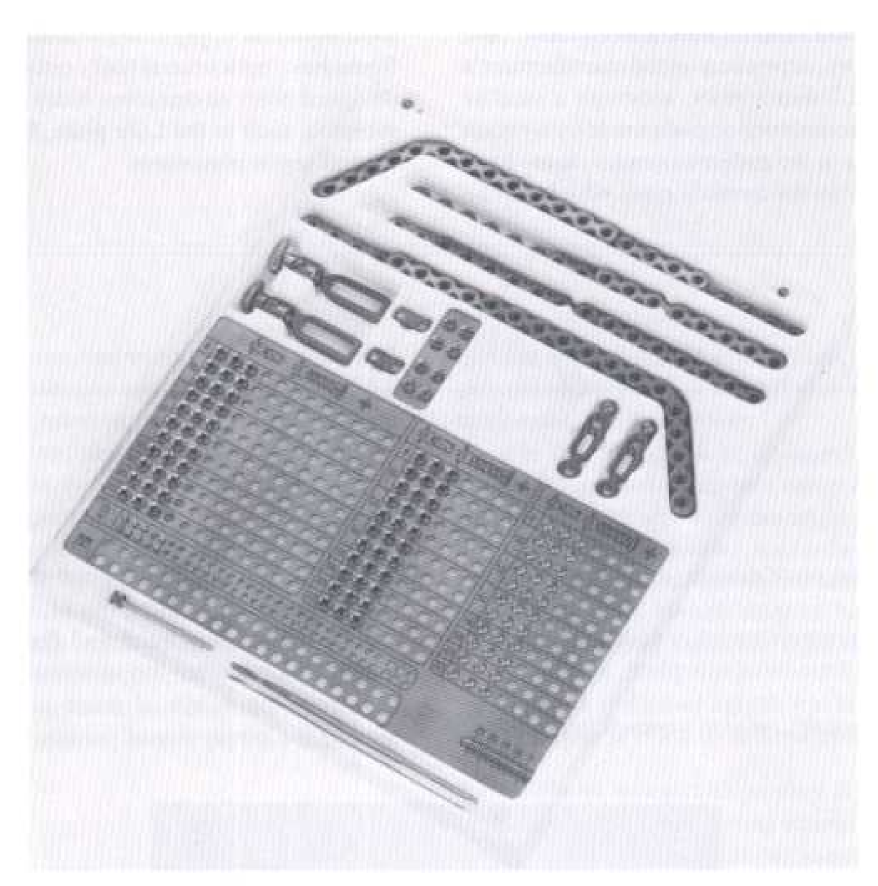


FIG. 1-40

Condylar head replacements These are mentioned here only to note that they exist. They come in various designs, but the specific utilization of these devices is complex and is not further discussed in this atlas.

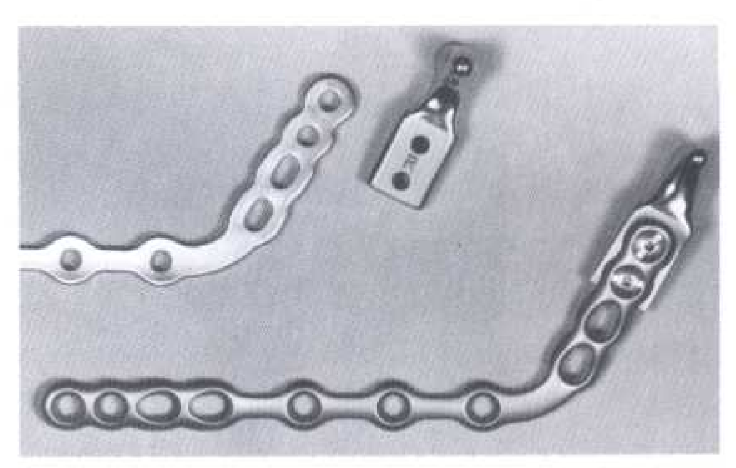


FIG. 1-41

Mandibular Compression Plates

Mandibular compression plates are designed for the application of compressive forces across a mandibular fracture. Unlike miniplates, these require the placement of bicortical screws. A variety of designs is available, as depicted earlier. Most, including Synthes, Storz, Leibinger, Lorenz, and Luhr use 2.7-mm screws. There is also a 2.4-mm mandibular compression plate made by Synthes. The specific design and use of compression plates is explained in a step-by-step fashion in Unit 2, *Placing a Compression Plate and Screws*.

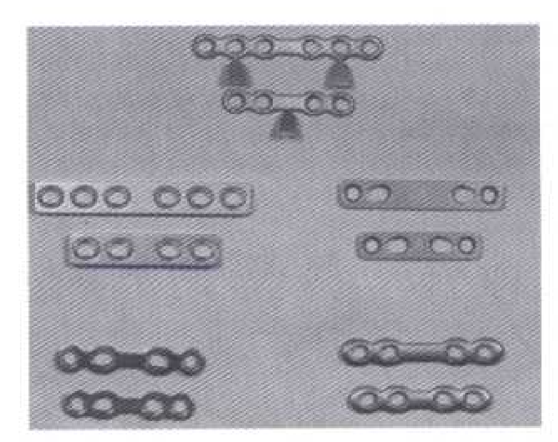


FIG. 1-42A

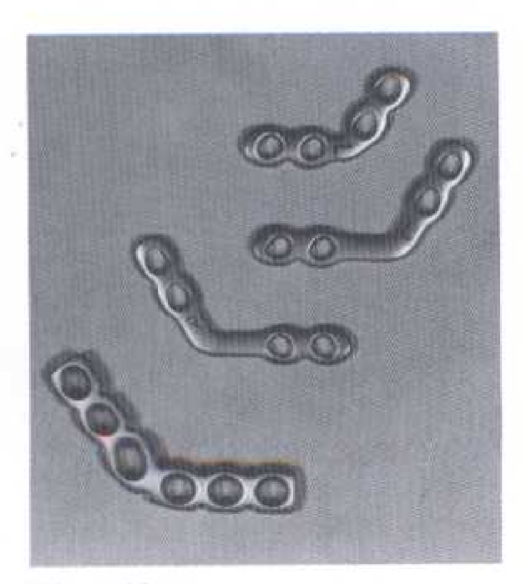


FIG. 1-42B

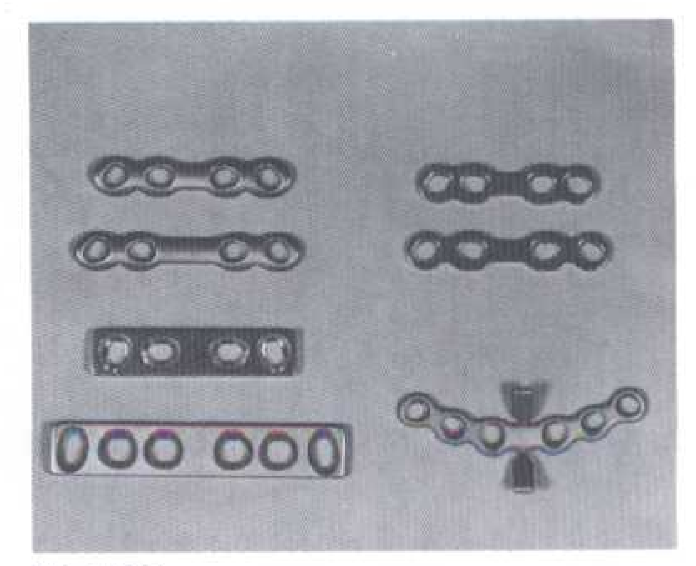


FIG. 1-42C

Mandibular Miniplates

Standard Mandibular miniplates are basically plates that are 2.0 mm that are designed specifically for use in the mandible. These are differentiated from midfacial miniplates, which in some systems, are thinner and, therefore, are not designed for use in the mandible. Great care must be taken to avoid the use of the wrong plate for the wrong indication, because this can easily result in failure as a result of inadequate biomechanical stability. Only the straight plates shown here are used for mandibular fixation.

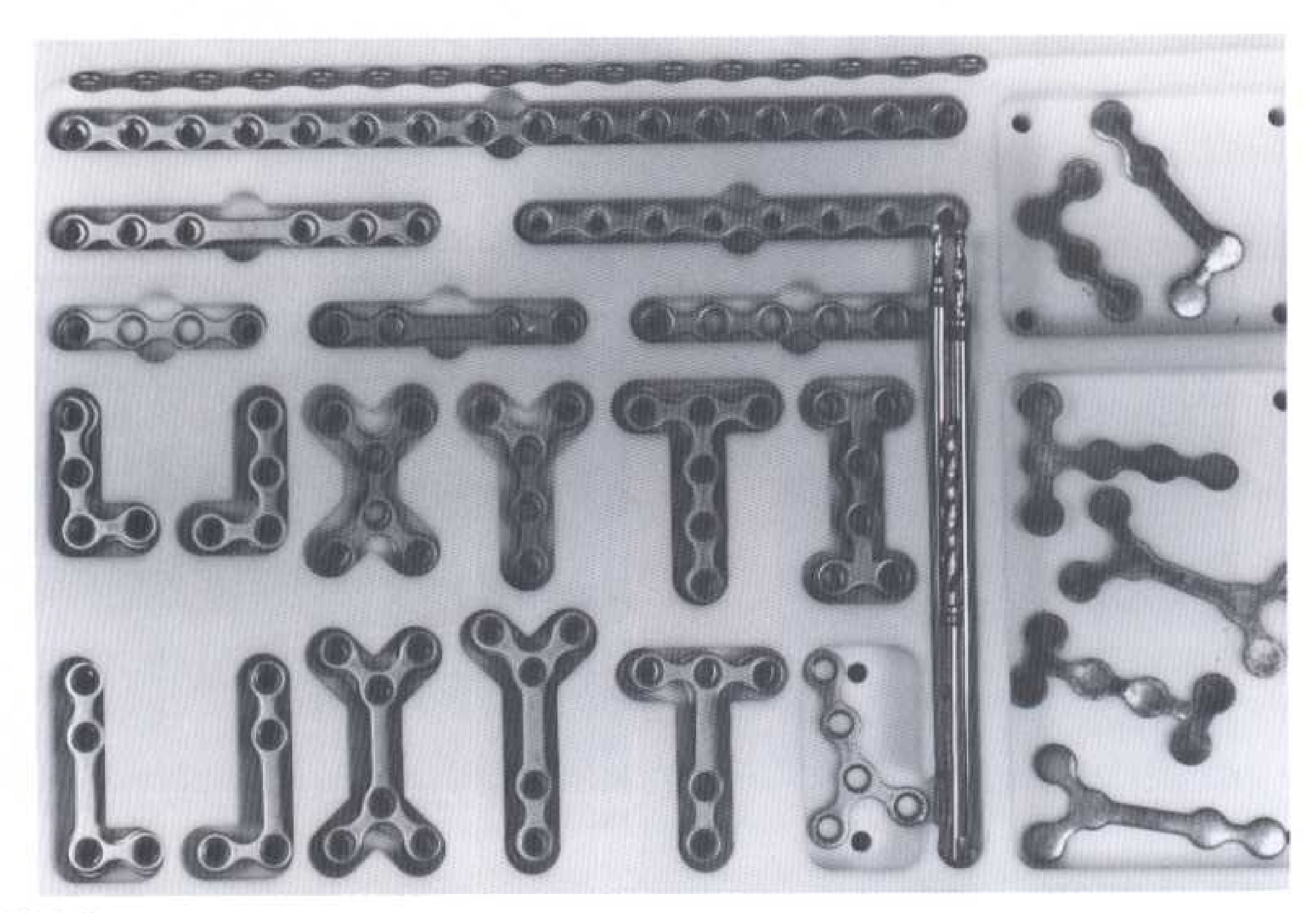


FIG. 1-43

A standard miniplate is generally a four-, six-, or eight-hole plate designed for neutral application. Mandibular miniplates are generally 1 to 1.2 mm in thickness. Their application and use are described in the appropriate sections in Units 2 and 5. Note that miniplating systems are utilized with monocortical self-tapping screws.

Three dimensional This is a unique design manufactured by Leibinger. It is basically a geometric shape (squares and/or rectangles) designed to add increased strength to the plate. Like the mandibular miniplate, 2.0-mm monocortical self-tapping screws are used.

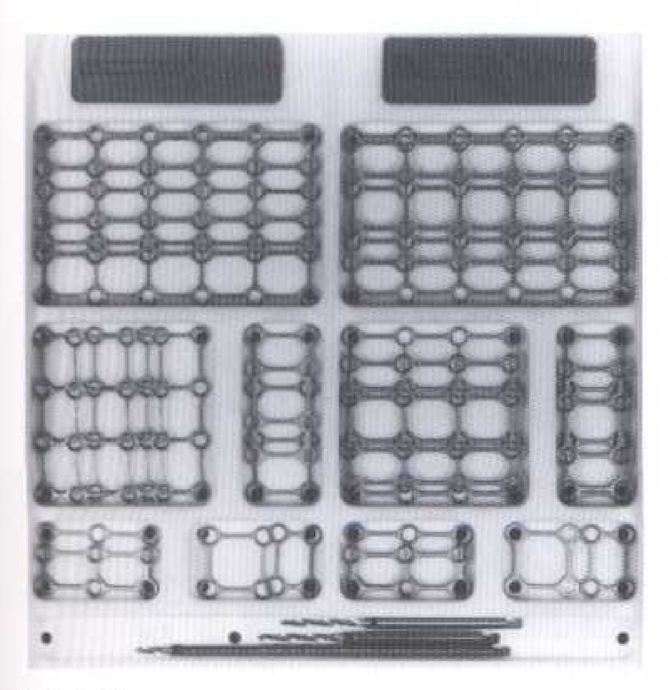


FIG. 1-44

NOTE: *It is very important to recognize that there are 0.6-mm thick and 1.0-mm thick plates that are identical in shape, other than their thickness. The 1-mm plates must be used for mandibular fixation, if adequate stability is to be obtained.*

Midfacial Miniplates

Midfacial miniplates come in the widest variety of shapes and sizes. Each company that produces these miniplates makes different sizes and shapes. They come with 2.0-, 1.7-, 1.5-, and 1.2-mm screws and 1.5- and 2.0-mm low-profile screw designs. Although all manufacturers recommend using these as self-tapping screws in most situations, the 2.0-mm Synthes screw is actually designed to be used with a tap.

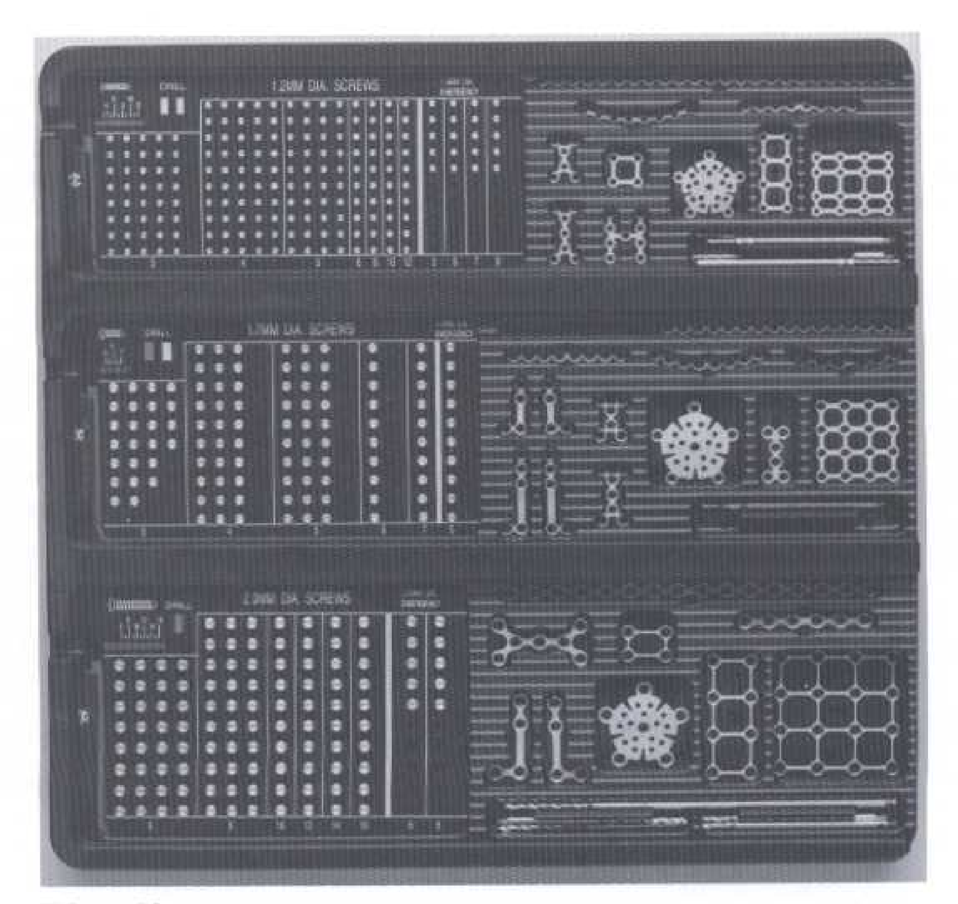


FIG. 1-45A

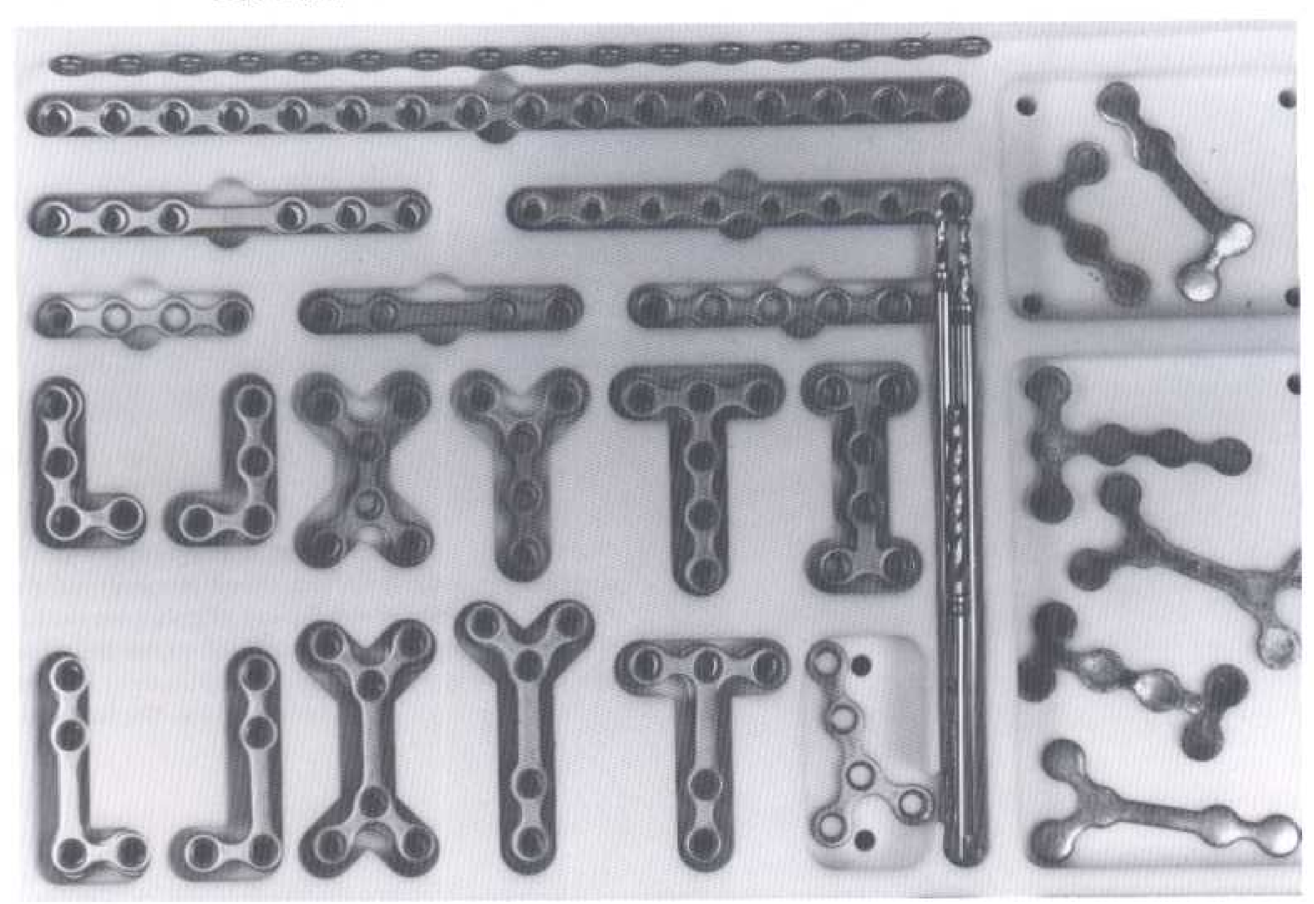


FIG. 1-45B

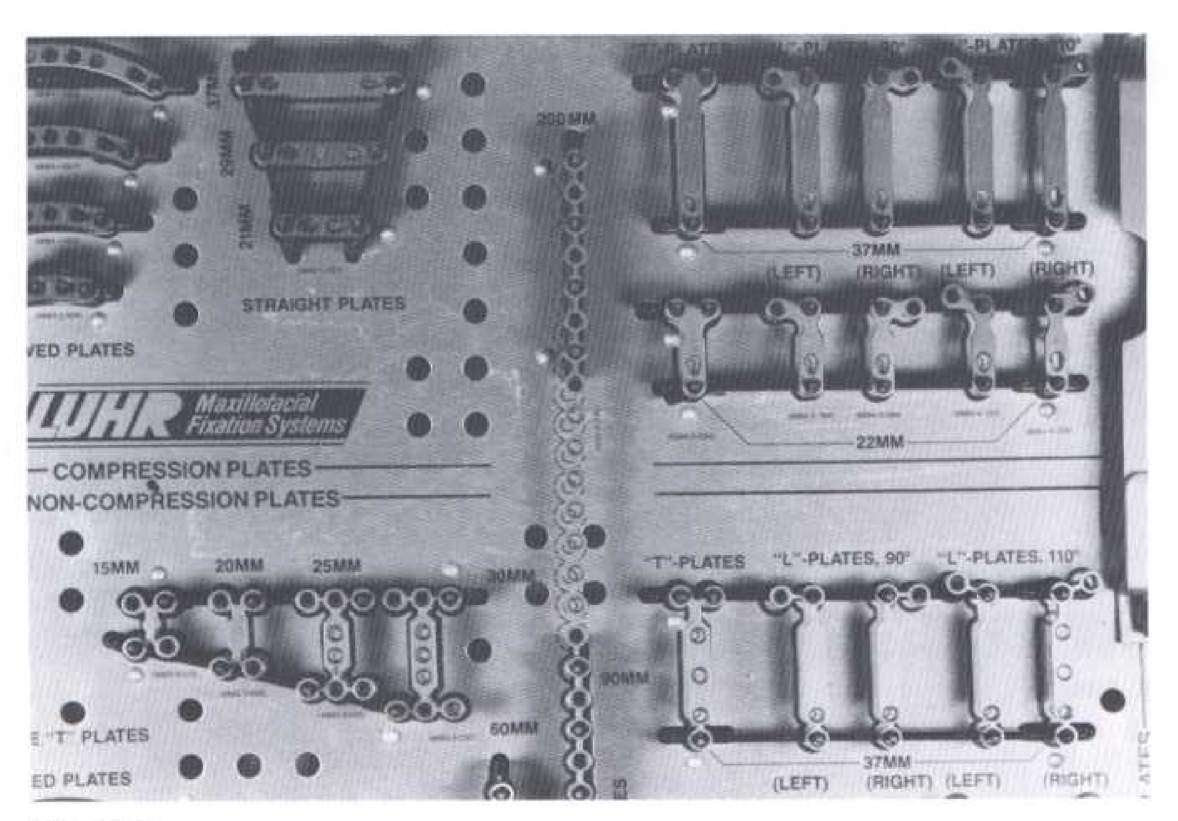


FIG. 1-45C

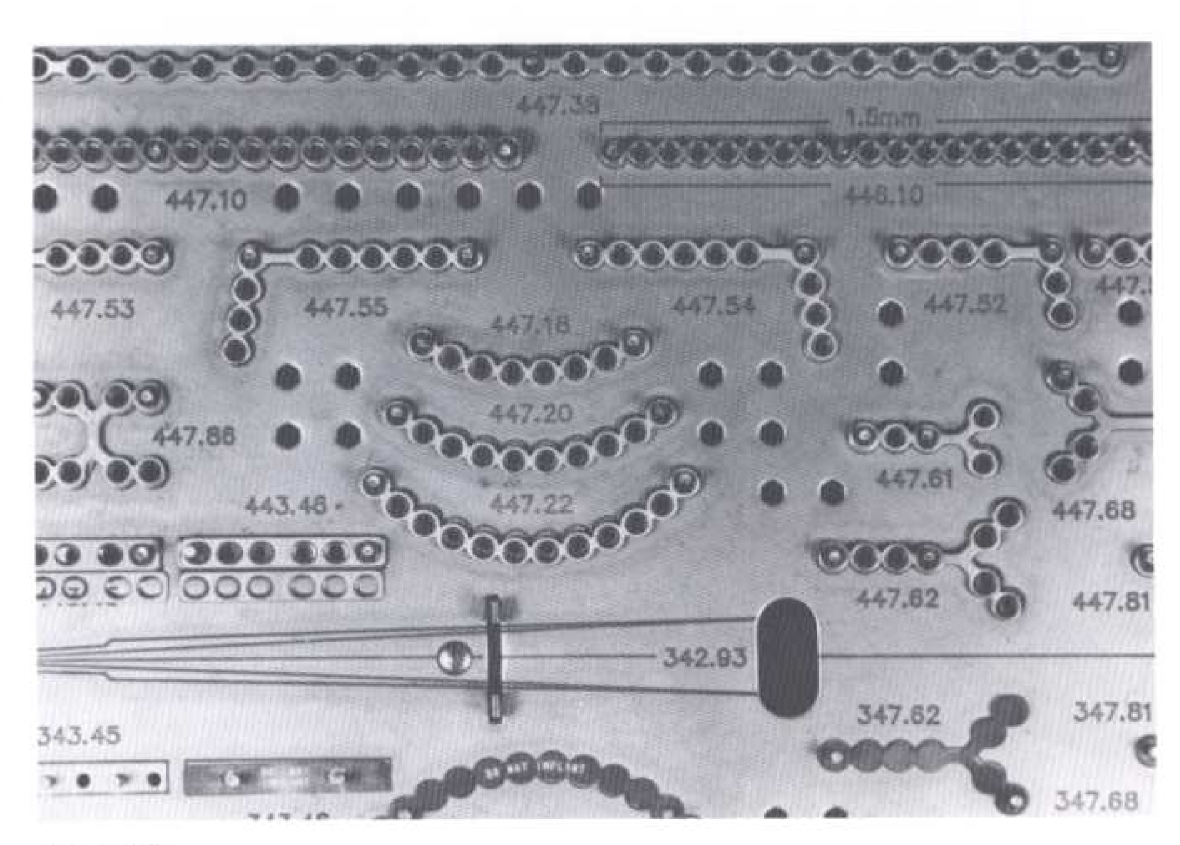


FIG. 1-45D

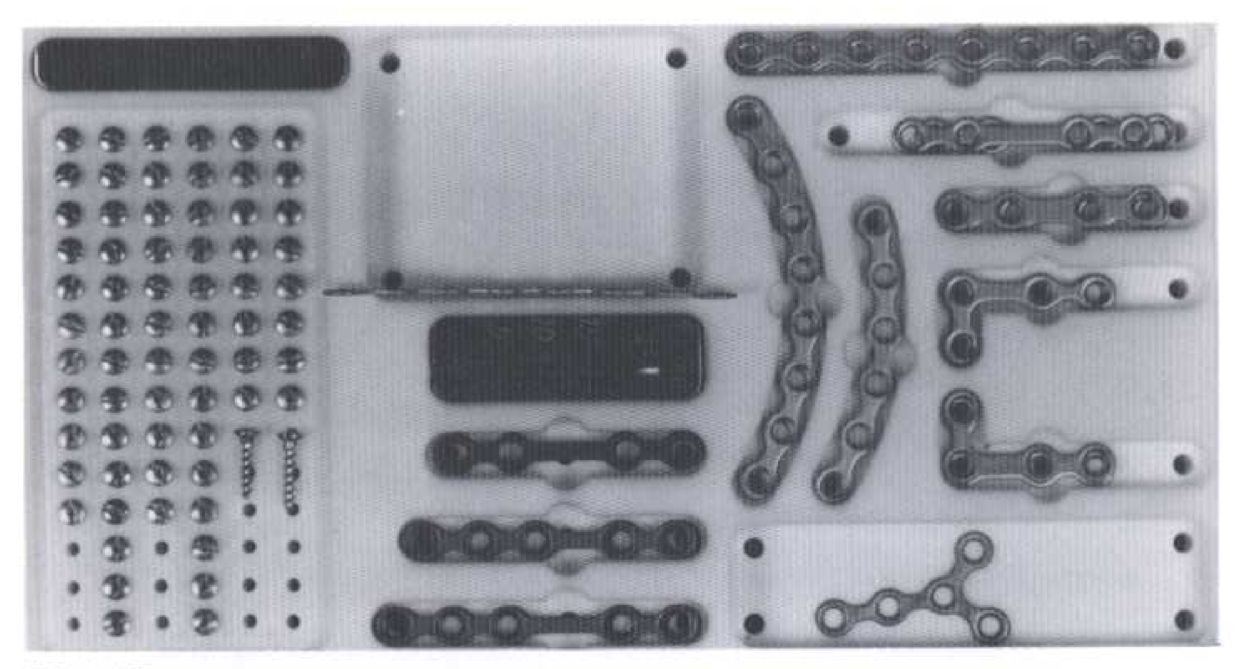


FIG. 1-45E

Microplates

In an effort to decrease constantly the size of the implants, the amount of metal implanted, and the potential for visibility and palpability of plates and screws through the skin, the manufacturers of these systems continue to decrease the sizes of the plates and screws produced. The smallest screws currently in use at the time of this writing are screws with a 1.0-mm thread. These are all designed to be self-tapping. They come in a variety of shapes and sizes by each manufacturer. Note that the Luhr microsystem, being made of Vitallium, offers the strongest plates and screws. The Leibinger microsystem offers "three-dimensional microplates," which in fact, are geometrical designs similar to the three-dimensional mandibular plates discussed previously. This geometrical design adds strength to the plates.

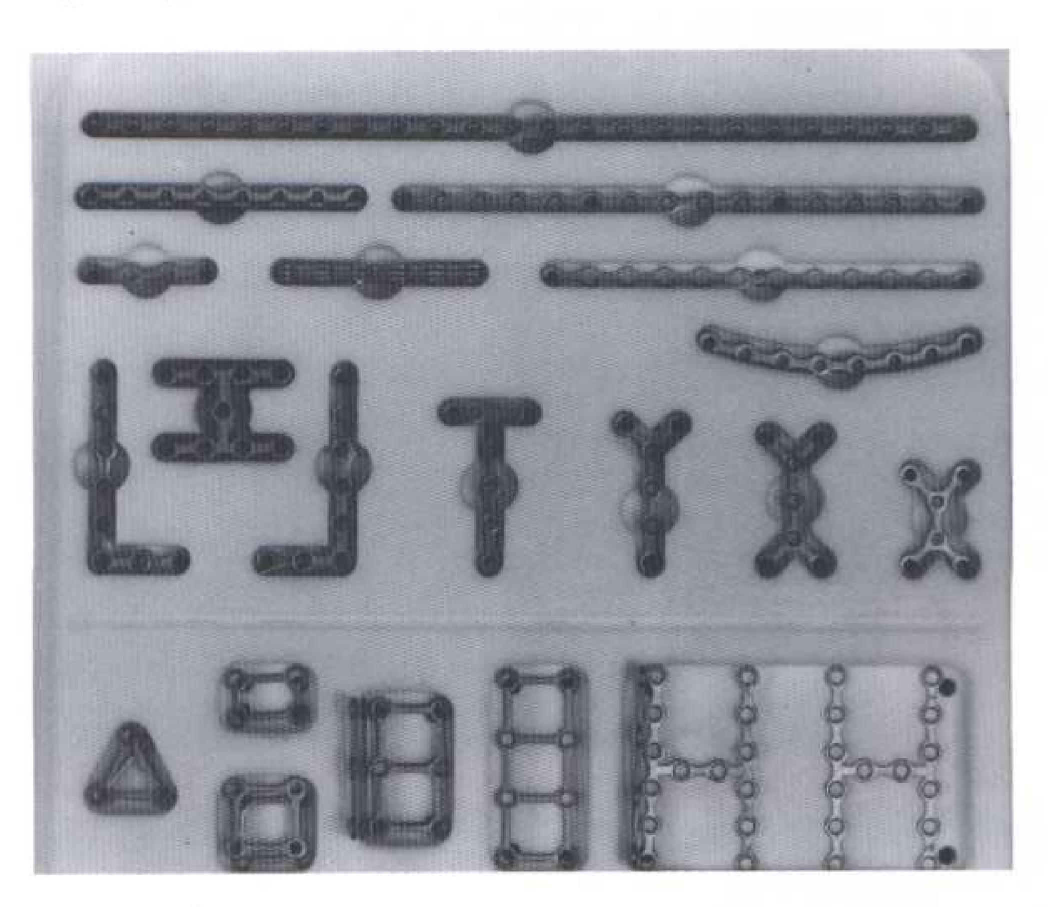


FIG. 1-46

NOTE: *Note that microscrews hold nicely in thin bone. In thicker bone, such as a thick calvarial bone and the frontozygomatic facial area, these screws have a tendency to break when they are being tightened. It is, therefore, wise to overdrill the hole in thick bone and also back the screw out periodically as it is being screwed in. If resistance during placement seems to peak, so that it feels like the screw might break, it might be wise to remove it.*

SCREWS

The main differences among screws are their sizes, their head designs, and whether they are designed to be self-tapping. The exception to this is the unique expansion screw used with the bone screws in the THRP system. Depicted here are a wide variety of shapes and sizes of screws designed by the various manufacturers. Note that self-tapping screws generally have flutes in their sides to allow for the escape of bone dust during the cutting of the thread. If there are no flutes, it is generally preferable to tap the hole with a tap first.

Great care should be used to select the appropriate drill, screw length, and screwdriver for each indicated use.

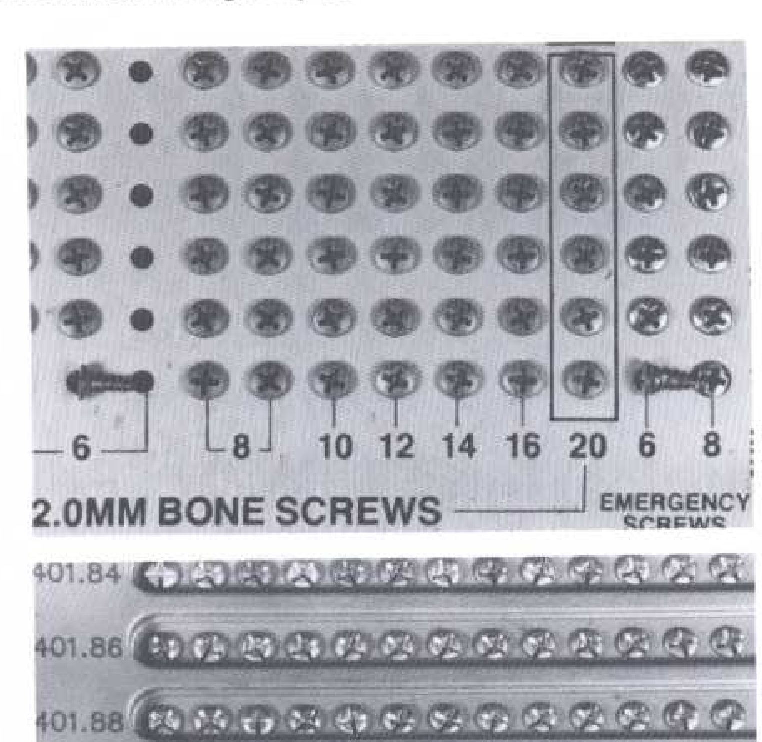


FIG. 1-47A

FIG. 1-47B

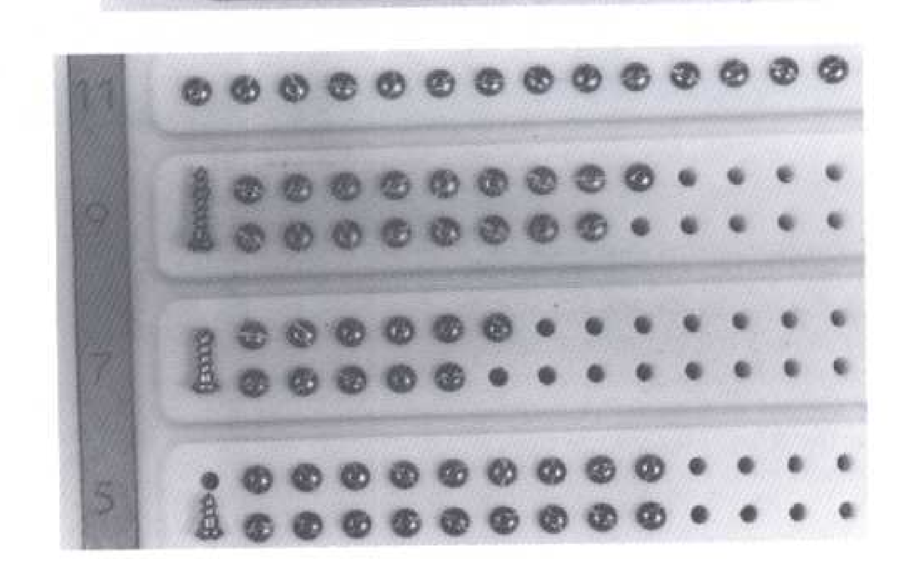


FIG. 1-47C

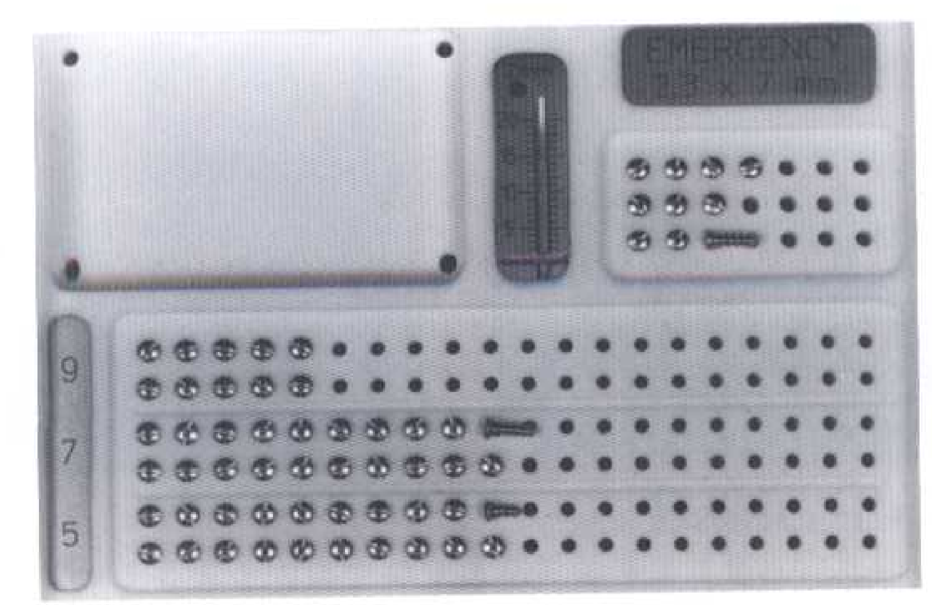


FIG. 1-47D

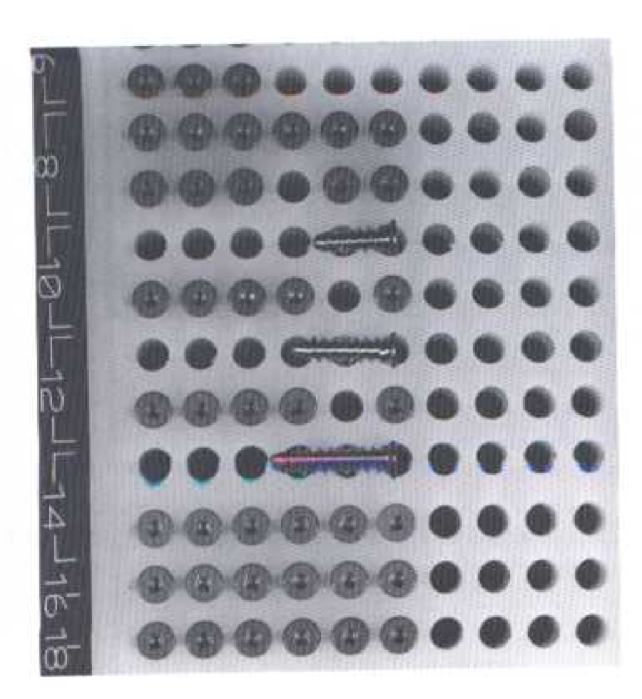


FIG. 1-47E

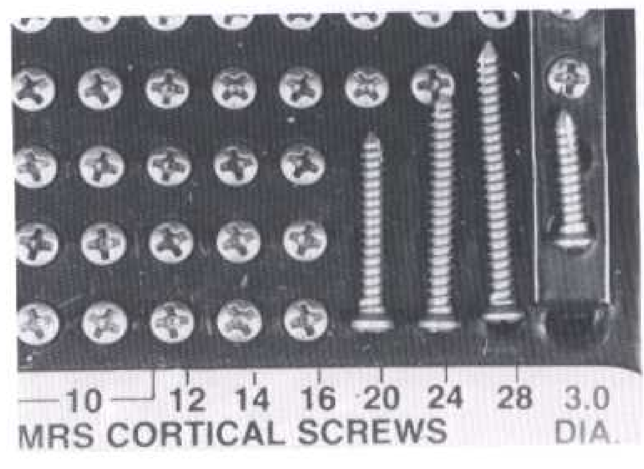


FIG. 1-47F

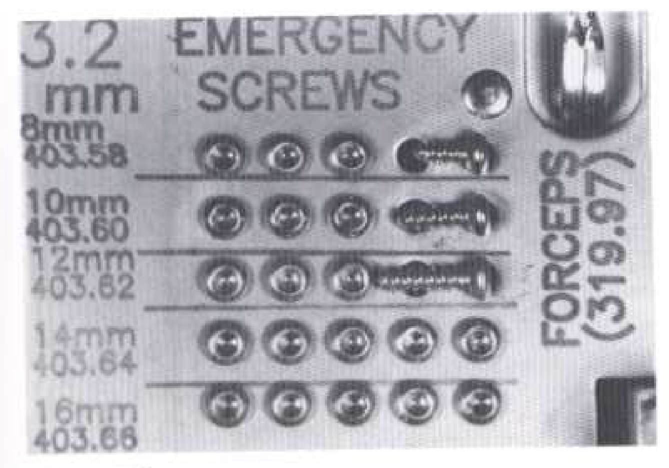


FIG. 1-47G

FIG. 1-47H

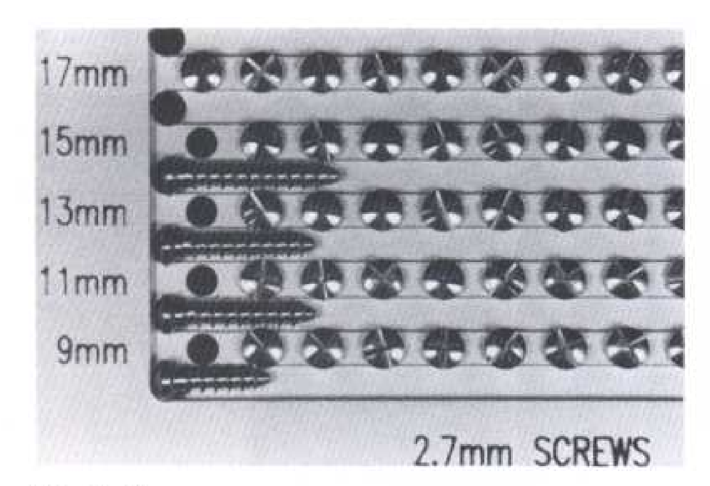


FIG. 1-47I

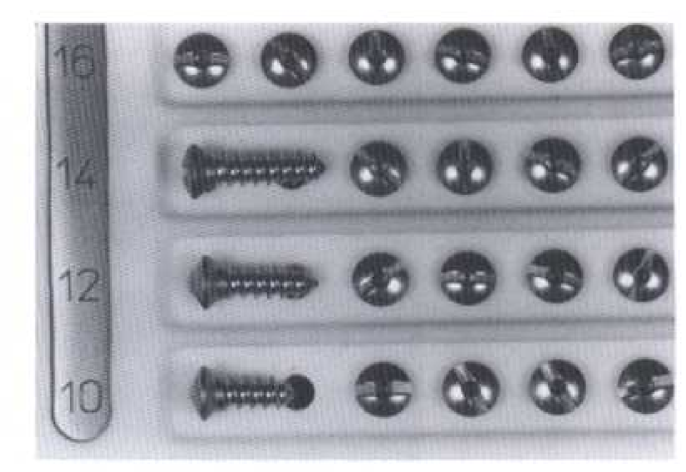


FIG. 1-47J

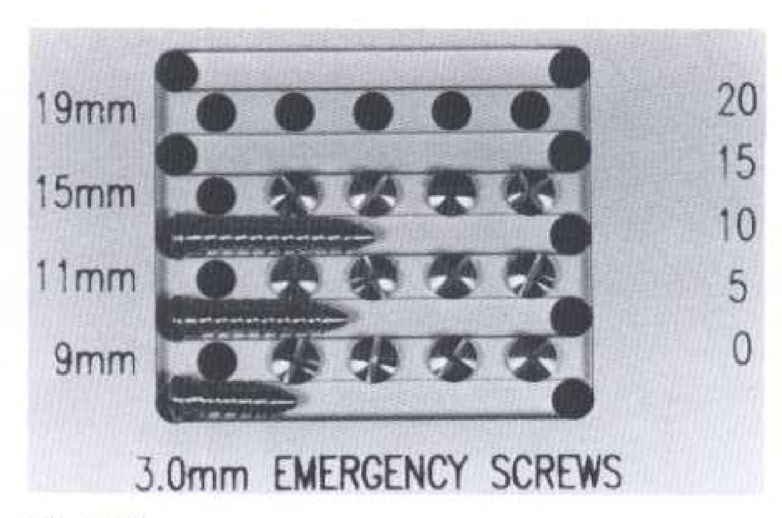


FIG. 1-47K

NOTE: *Note that microscrews hold nicely in thin bone. In thicker bone, such as a thick calvarial bone and the frontozygomatic facial area, these screws have a tendency to break when they are being tightened. It is, therefore, wise to overdrill the hole in thick bone and also back the screw out periodically as it is being screwed in. If resistance during placement seems to peak, so that it feels like the screw might break, it might be wise to remove it.*

UNIT II

Basic Principles

UNIT OUTLINE

CHAPTER 1

Principles of Rigid Fixation

Rigid fixation techniques for bone repair are based on several principles and premises.

1. A screw of proper strength and design will hold in bone over time.
2. A properly designed and properly positioned rigid plate will impart its strength to a fractured or osteotomized bone when it is properly fixed to that bone with screws.
3. Devices can be fixed to fractured and osteotomized bones so that the bones remain fixed together despite full loading in function.
4. Additional fixation points generally yield a stronger fixation.
5. If the rigid fixation device is strong enough, and if enough fixation points are used, a bone defect can be bridged with the fixation device so that the remaining segments can support a functional load.
6. Corollary: A rigid plate screwed across the fracture will not impart stability, unless
   a. The fixation device is appropriate for the particular anatomical and physiological need,
   b. The number of fixation points is adequate, and
   c. There is strict adherence to biomechanical principles.

The key to successful rigid fixation (i.e., maximizing successful outcomes and minimizing complications and failures) is a combination of

1. Knowledge of the biomechanical principles that form the basis for rigid fixation techniques and
2. Adherence to these principles to whatever extent is possible.

CHAPTER 2

Basic Biomechanics

The strength of a repair must be adequate to overcome any forces that will act on the repaired bone during function.

1. When there is no force borne by the bone (e.g., the anterior wall of the frontal sinus), minimal fixation is needed. (Indeed, frontal sinus fractures can be repaired using wires or microplates, with a minimum number of fixation points.)

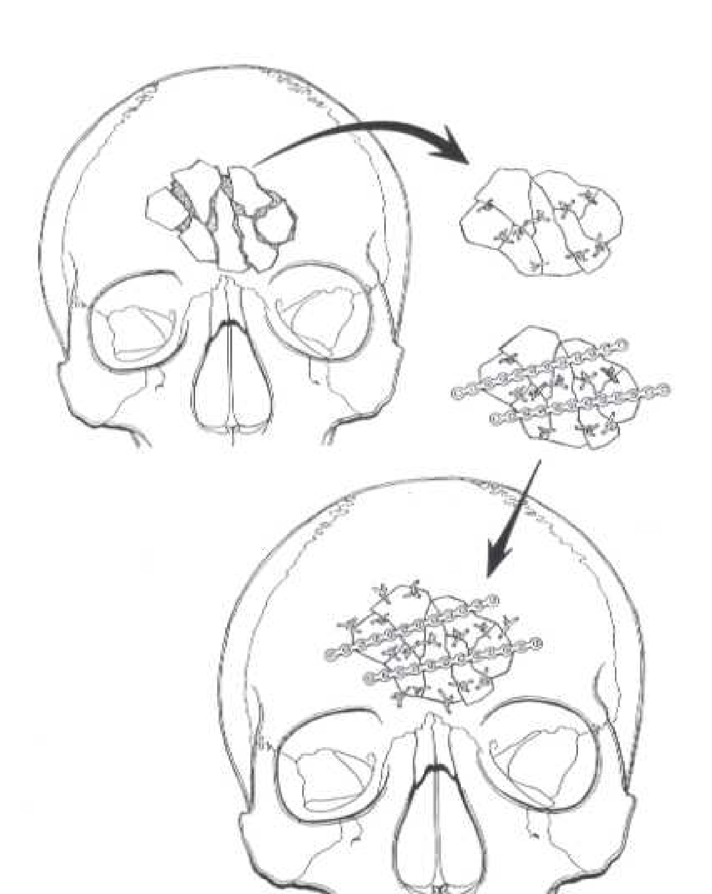


FIG. 2-1

2. When forces act on a bone in function, they may compress the fragments together (e.g., the inferior mandibular body),

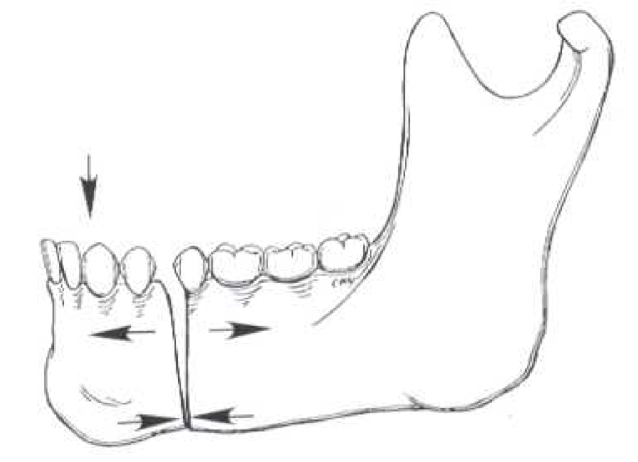


FIG. 2-2

they may pull them apart (e.g., the alveolar area of the mandible), or they may be torsional in nature, tending to rotate the fragments (as in the mandibular symphyseal region).

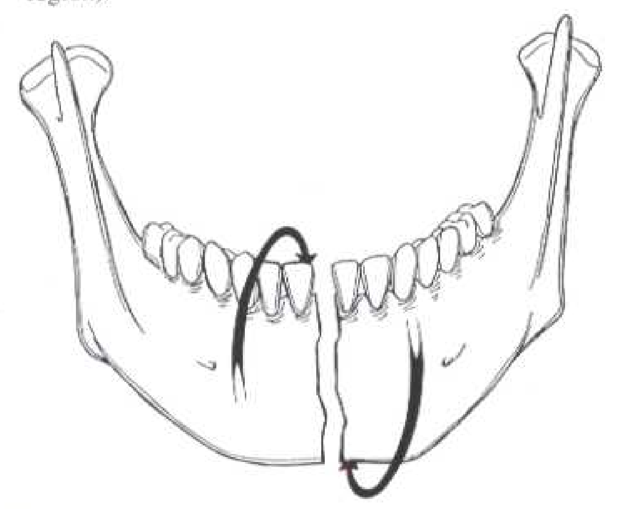


FIG. 2-3

The fixation must be adequate to overcome these forces.

NO FORCE

Any simple fixation (even wire fixation) is adequate if it holds the bones in position so that they can heal.

DISTRACTING/COMPRESSIVE FORCES

In some areas, the majority of force on a bone is compressive in function (e.g., the maxilla with a Le Fort I fracture or osteotomy). In this situation, the fixation must be strong enough to hold the bones in a proper position during healing so that they do not shift in position from shearing or overcompression. Thus, miniplates work well in the maxilla.

In many cases, when compressive forces occur across one portion of a fracture (the pressure area), another portion will be distracted (the traction area).

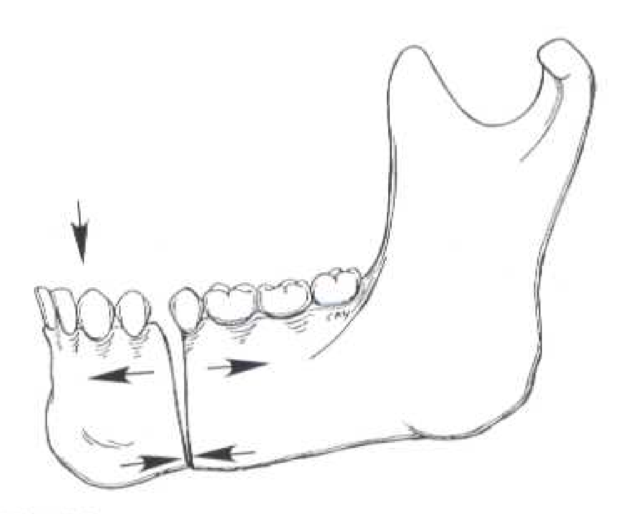


FIG. 2-4

The pressure area will tend to be held together naturally, but the traction area will be pulled apart during function. This will create mobility of the fragments and lead to nonhealing (nonunion). Thus, fixation must overcome the traction forces that occur during function.

If a device is used to overcome the tractional forces, the compressive forces that occur during function will tend to be distributed across the entire area, leading to healing. This principle is called tension banding, and it has been the mainstay of mandibular fracture repair for many years. This may be accomplished in several ways.

Traction Wire/Tension Band

A wire may be used to hold the traction area of the bone together if it is strong enough to overcome the distracting forces. In the mandible, an arch bar may serve this purpose. Sometimes, teeth on both sides of the fracture are wired together.

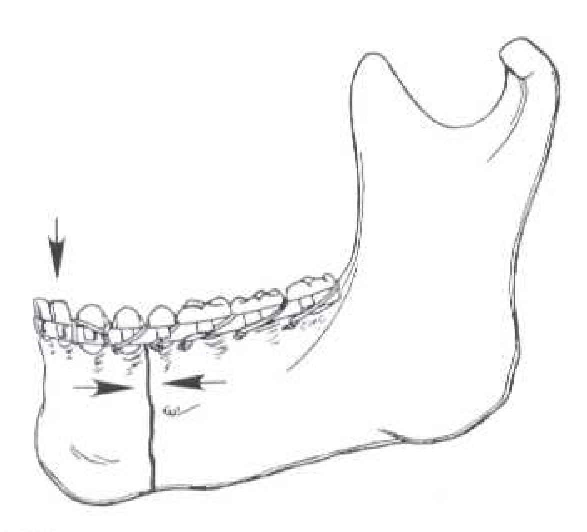


FIG. 2-5

Miniplate Approach

A miniplate may be used to hold the traction side of a fracture or osteotomy together. Again, it must be strong enough to overcome the distracting forces. The principle of miniplate fixation of mandibular fractures depends on placement of the miniplate along the tension area, thereby holding the traction area together at rest and in function while allowing the compressive forces that occur naturally in function to be distributed across the entire fracture. At rest, a single miniplate holds the fracture together.

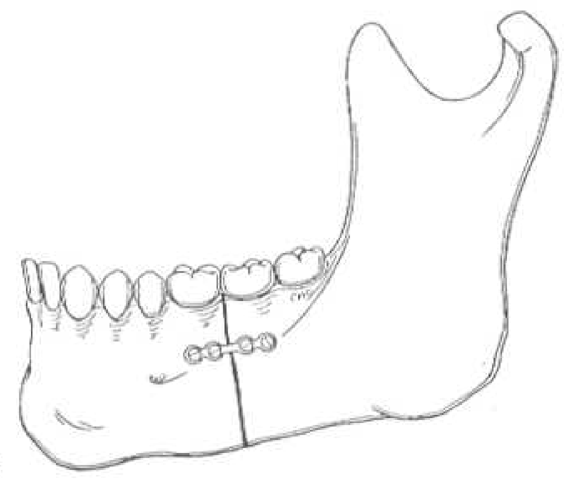


FIG. 2-6

In function, the miniplate along the traction side prevents distraction of the fragments and causes the naturally occurring compressive forces to be distributed along the full length of the fracture.

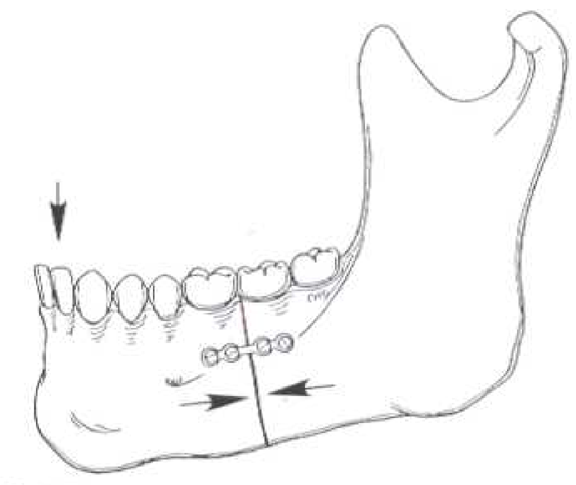


FIG. 2-7

When the forces vary during phases of function (e.g., the angle region) or when torsional forces also act on the area (e.g., the symphyseal region), then two miniplates must be used if dependable stability of fixation is to be achieved.

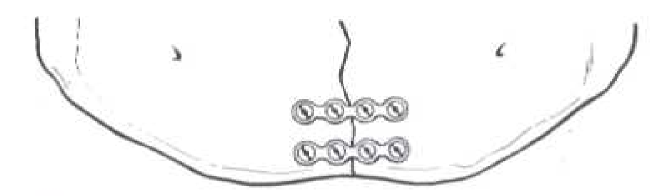


FIG. 2-8

Note that the proper position for miniplate fixation of mandible fractures has been worked out experimentally by Professor Maxime Champy and is depicted in the figure. This is referred to as "Champy's Ideal Line of Osteosynthesis."

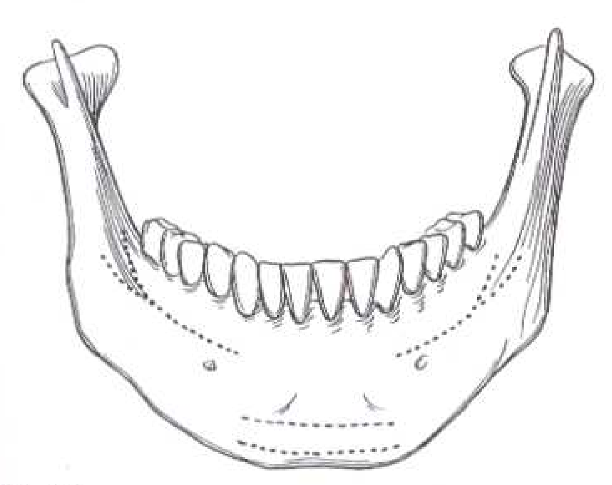


FIG. 2-9

To avoid injury to tooth roots and/or the inferior alveolar nerves, the miniplate is applied using monocortical screws. These are placed 1.5 to 2 crown heights below the gingival margin to avoid the tooth roots. This will generally place them between the teeth and the nerve. If the nerve canal is entered, the short monocortical screw should not injure the nerve itself.

Compression Plate Approach

Compression plating of mandible fractures generally requires the use of a tension banding technique because a mandibular compression plate requires bicortical screws, which can only be placed along the biomechanically unfavorable pressure side of the fracture (i.e., the inferior border) to avoid injury to the teeth and nerves. Thus, a compression plate may be used along the basal border (pressure side) of the mandible, but only if a tension band technique, such as an arch bar or miniplate, has been used first. A compression plate should not be applied to the basal border of the mandible in the absence of some form of tension band fixation of the traction side. Compression of the pressure side without tension banding of the traction side will result in distraction of the traction side. This will result in an unstable fixation and probable failure and nonunion.

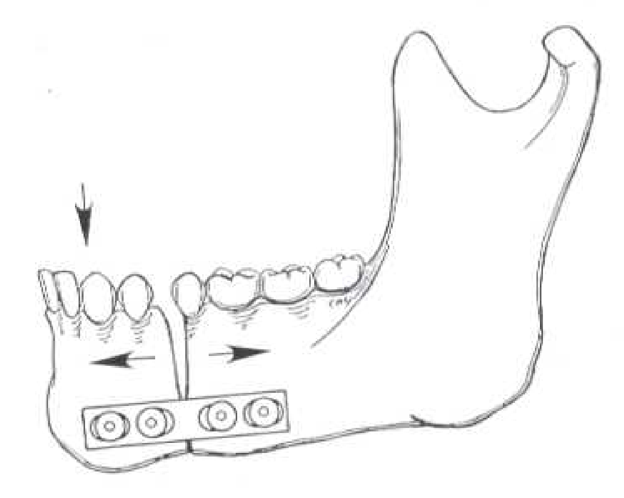


FIG. 2-10

Note that the same principles apply when using the mandibular reduction forceps. Compression of the basal border without prior tension banding of the traction side (alveolar border) will result in distraction of the alveolar border.

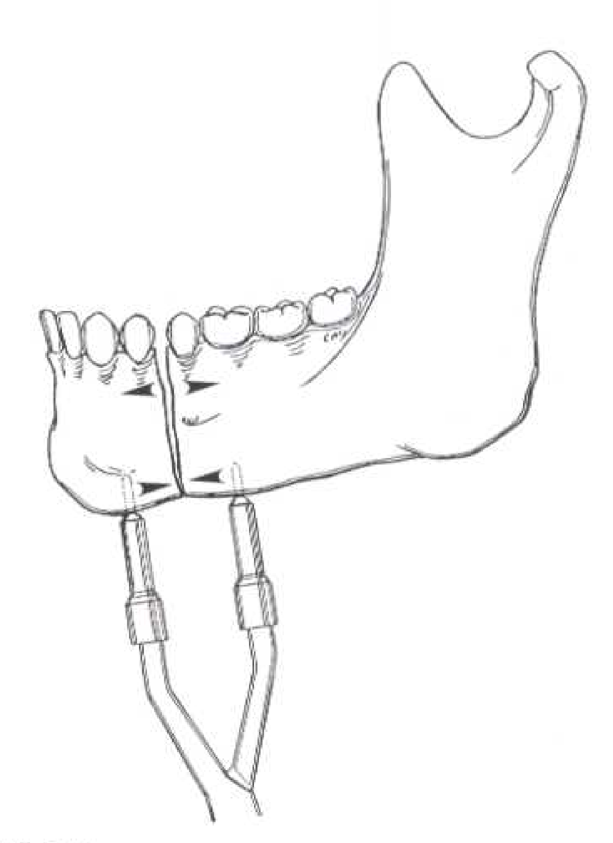


FIG. 2-11

When a tension band has been applied properly, the mandibular reduction forceps can be safely and successfully used to compress the basal border (compression side), resulting in compression along the length of the fracture.

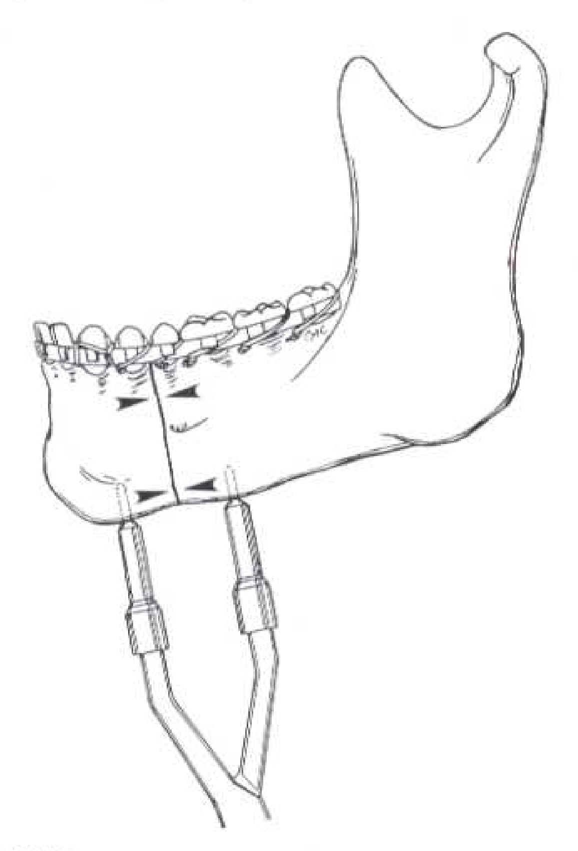


FIG. 2-12

The only seeming exception occurs when a compression plate may be placed centrally or along the traction side. (This is not a true exception because the compression plate is not placed along the basal border. This approach cannot be used for most mandible fractures because the bicortical compression screws will damage tooth roots and/or the inferior alveolar nerves. It can, however, be used occasionally in the symphyseal region, particularly if the mandible is edentulous.)

Eccentric Dynamic Compression Plate (EDCP)

This can be applied along the inferior mandible (pressure side). This unique device is designed to compress the traction side and the pressure side from its position along the basal border of the mandible.

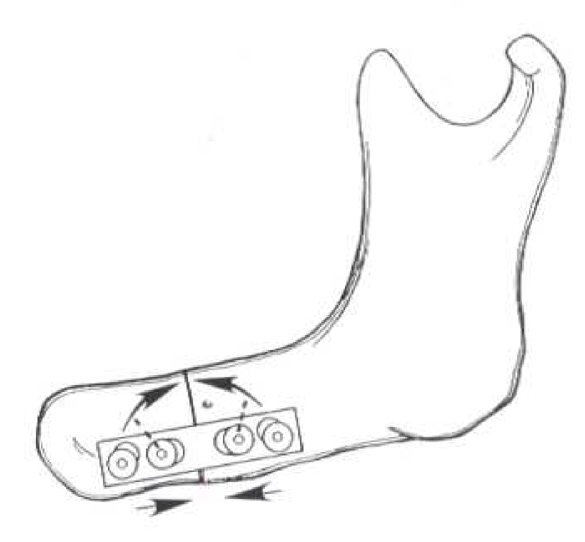


FIG. 2-13

NOTE: *Precompression of the traction side is necessary if this device is to be used successfully. This can be accomplished successfully by using a modified towel clip to hold the alveolar portion of the fracture together.*

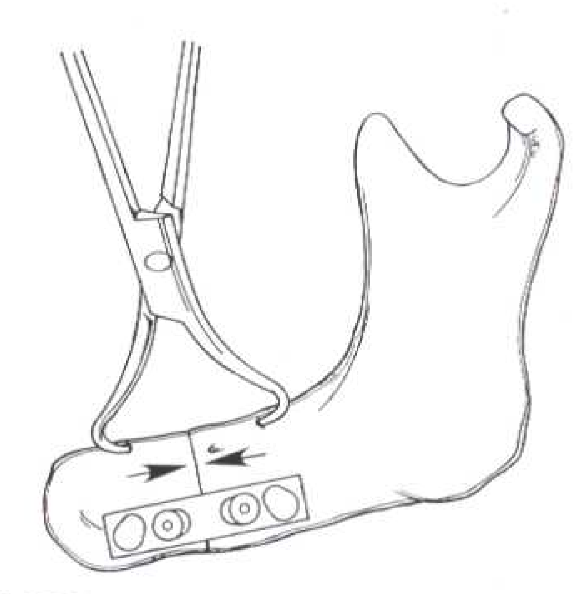


FIG. 2-14

This can also be accomplished by using the mandibular reduction forceps with side rollers to compress the alveolar border. Note that the initial compression of the basal border with the forceps results in distraction of the alveolar border (as expected).

FIG. 2-15

Upward force is then applied to the inferior border by using the side rollers. This results in compression of the alveolar border.

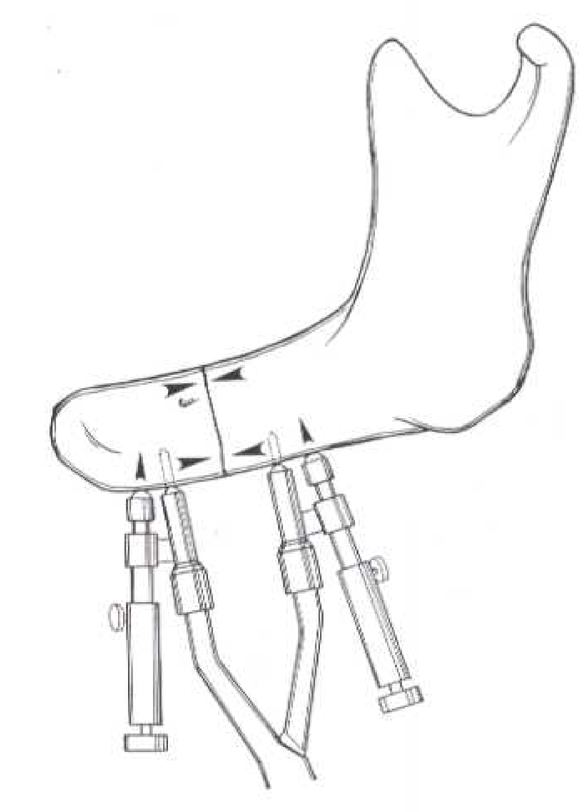


FIG. 2-16

Similarly, without precompression of the alveolar border with either a bone-holding clamp or a mandibular reduction forceps with side rollers, placement of the axial compression screws will distract the tension side of the fracture, and the superiorly directed forces provided by the diagonal (or vertical) holes will be inadequate to provide adequate stabilization.

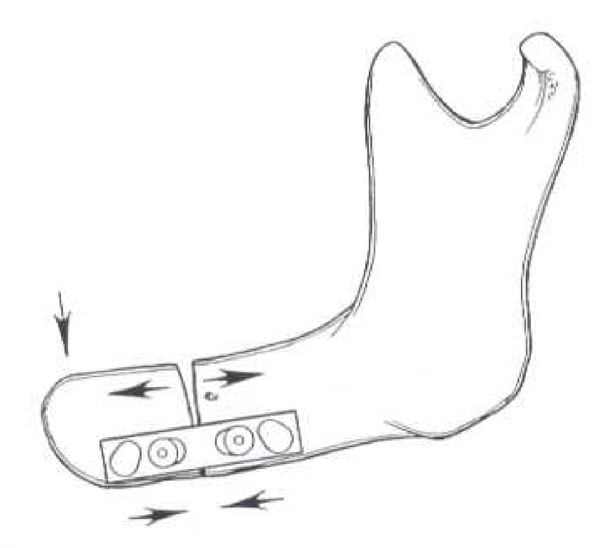


FIG. 2-17

When properly used, the EDCP will provide compression of both the basal and alveolar borders from its basal position.

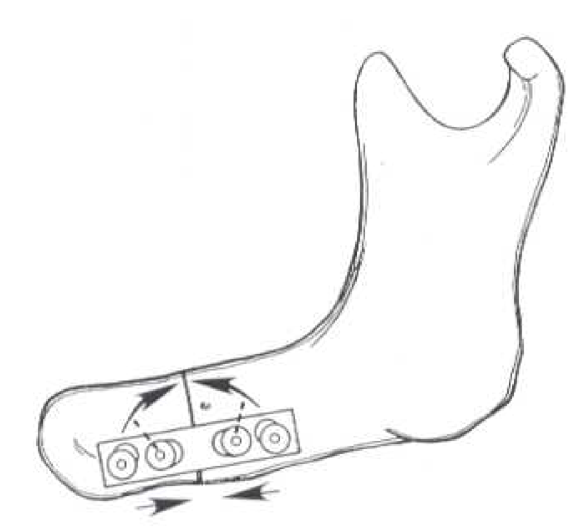


FIG. 2-18

Long (Reconstruction) Plate

A long strong plate with multiple fixation points can be placed wherever it is feasible. If there are at least four or five bicortical screws on each side of a fracture, even placement on the biomechanically less desirable compression side will prevent mobility in all areas of the bone and, thus, provide adequate stabilization for healing (even without tension banding).

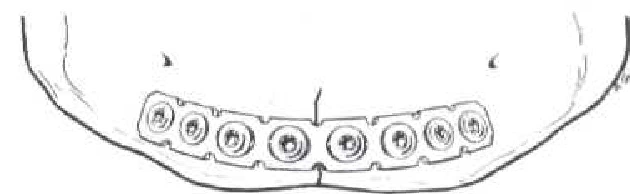


FIG. 2-19

TORSIONAL FORCES

These can generally be overcome in one of two ways as follows:

1. The first is to use a long strong fixation device with multiple fixation points. As the length of the appliance and the number of fixation points increase, the rigidity of the repair and its ability to overcome the torsional forces will also increase. (Thus, a long mandibular reconstruction plate with four or five screws in each fragment will support a symphyseal fracture even without tension banding.)

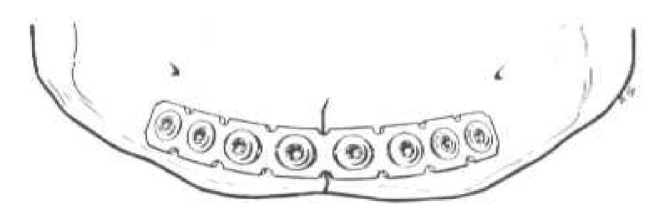


FIG. 2-20

2. Multiple fixation points using more than one fixation device will overcome torsional forces. In the mandible, this can be accomplished using any of the following approaches:

   a. Two miniplates can be used. The upper miniplate overcomes distracting forces, and the addition of a second miniplate overcomes torsional forces.

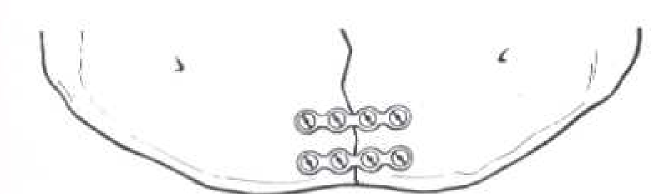


FIG. 2-21

   b. A miniplate tension band can be combined with a compression plate. Again, the upper miniplate overcomes distracting forces, and the compression plate strengthens the fixation by adding compression while also overcoming torsional forces.

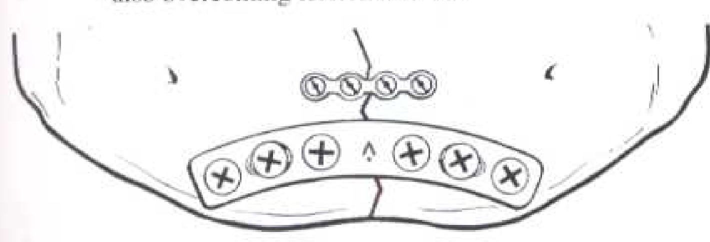


FIG. 2-22

   c. An arch bar tension band can be combined with a compression plate. The arch bar serves as a tension band and overcomes the distracting forces, and the compression plate again strengthens the fixation by adding compression while also overcoming torsional forces.

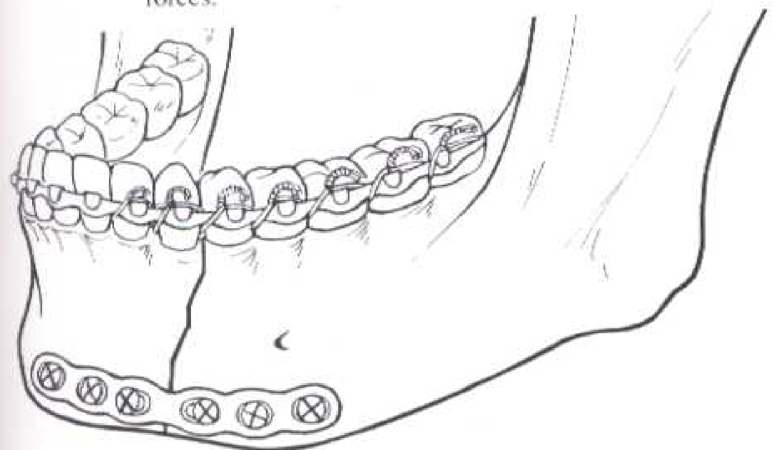


FIG. 2-23

OVERLAPPING FRAGMENTS

Overlapping fragments, such as those seen in oblique fractures or in the placement of bone grafts, are best stabilized by using lag screws. Multiple lag screws will overcome shearing, torsional, and rotational forces that would otherwise mobilize the fragments.

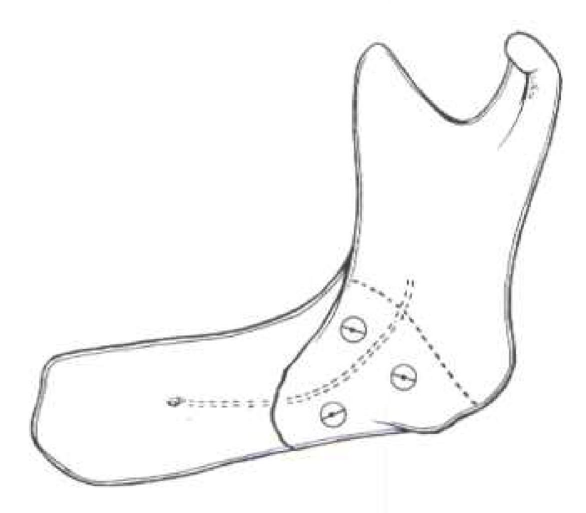


FIG. 2-24

TABLE II.2 *Typical forces and requirements (anatomical areas and fractures, as gross approximations)*

Area	Forces	Repair technique
Frontal/cranial	Minimal	Wires Microplates Three-dimensional microplates Miniplates
Zygomatic tripod (F-Z)(Z-M)	Moderate (rotational)	Minicompression plate Miniplate (multiple sites) Three-dimensional microplate (multiple sites)
Zygomatic arch	Moderate (masseteric pull)	Wires Microplates
Infraorbital rim	Minimal	Wires Microplates
Le Fort I, II buttresses	Moderate (compressive)	Miniplates Three-dimensional microplates (eight hole) Bone grafts with lag screws
Anterior maxilla	Minimal	Wires Microplates
Nose, nasoethmoid	Minimal	Wires Miniplates Microplates
Mandible	Maximal (torsional, distracting, compressive)	Miniplates Three-dimensional miniplates Compression plates Reconstruction plates (with utmost attention to biomechanical principles)

F, frontal; Z, zygomatic; M, maxilla.

CHAPTER 3

Principles and Techniques of Screw Placement

SCREW THROUGH A PLATE, NO OVERLAPPING FRAGMENTS

Principles

The basic concept of screw fixation is that the hole in the bone admits the shaft of the screw, and the threads extend beyond the hole into the surrounding bone. A snug fit of the shaft in the drilled hole prevents the screw from wobbling, which can lead to loosening in a biological system. The screw threads must also hold in the bone, making careful attention to the techniques of drilling, tapping, and screw placement essential. A cylindrical hole will hold more threads than a funnel-shaped hole.

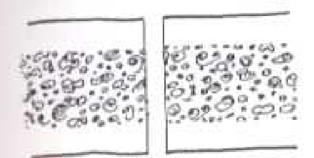
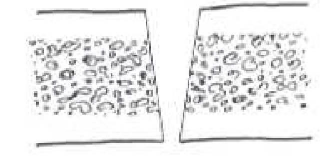



FIG. 2-25A

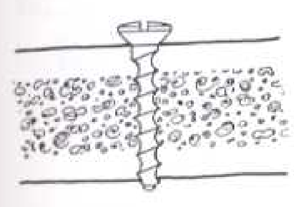
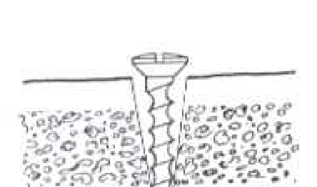



FIG. 2-25B

The use of a drill guide while drilling will decrease any tendency toward widening of the hole entrance.

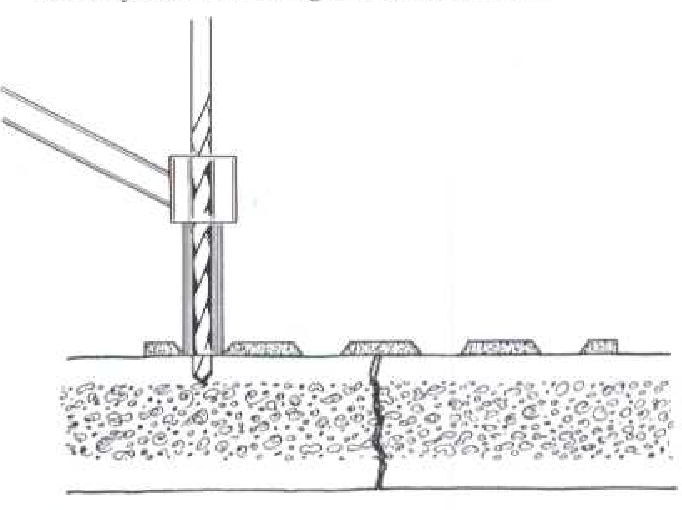


FIG. 2-26

Some screws are self-tapping. These have sharper threads to cut the bone as they are placed and tightened. They also have flutes to allow the bone debris to escape. Nonself-tapping screws require the use of a tap to cut the thread in the bone prior to the placement of the screw. Like a self-tapping screw, the tap has cutting threads and is fluted. After careful tapping, the screw is placed. Of course, the thread on the tap must correspond exactly to the thread on the screw.

Technique

The proper-sized drill bit is selected. This should correspond to the size of the screw shaft (not the thread size). The drill bit should be sharp. (Dull bits should be discarded and not reused.)

A drill guide is used (when available) to minimize wobble of the bit as it drills the hole. Irrigation is used to cool the bone during drilling. Minimal pressure is used for drilling, and the drilling is stopped immediately after passing through the bone. When a monocortical screw is being placed, care must be used to stop immediately after penetrating the first cortex.

The depth of the hole is measured using a depth gauge. When a bicortical screw is being placed, care must be taken to make sure both cortices have been grasped with the depth gauge.

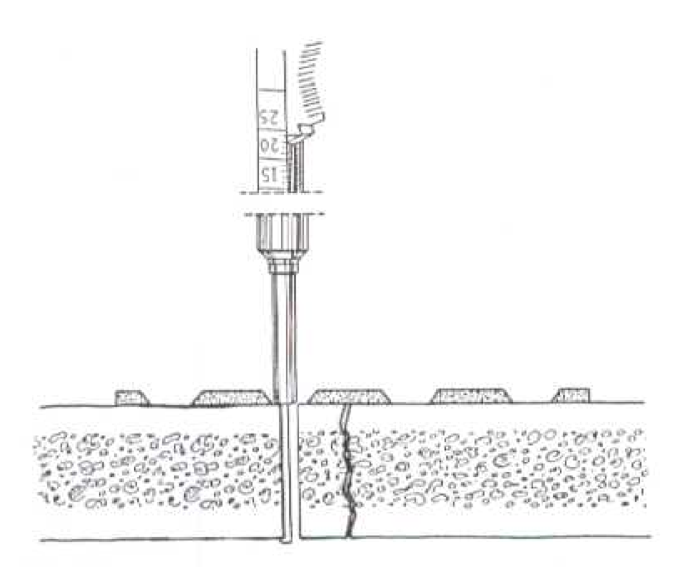


FIG. 2-27

If the screw is not self-tapping, then the hole is now tapped. The tap is screwed clockwise into the hole, making sure to proceed in the same direction and to avoid wobble. The tap is the size of the screw thread. (The depth gauge should not be replaced because it may damage the threads in the bone.)

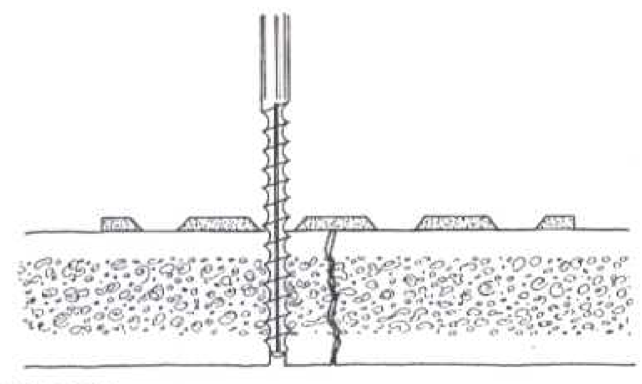


FIG. 2-28

The screw is now placed in the hole. Various screw-holding devices are available to help hold the screw in position while it is being placed and tightened. (When a screw hole strips, i.e., the screw will not tighten and continues turning, an "emergency screw" is placed (discussed later).

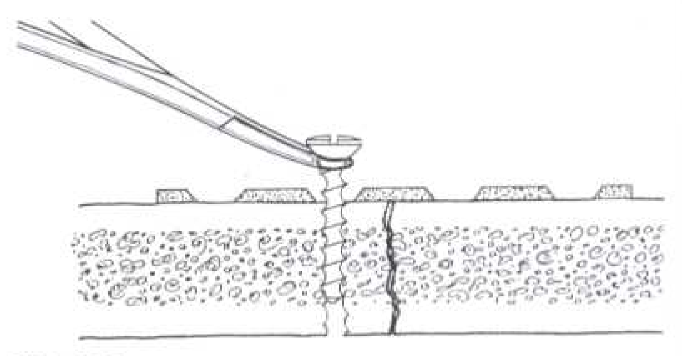


FIG. 2-29

NOTE: *This merely describes the steps for screw placement. Placement of neutral versus compression screws in a plate is discussed subsequently.*

LAG SCREW (OVERLAPPING BONE FRAGMENTS)

NOTE: *Contrast this with the section on the positioning screw.*

The key to the proper repair of oblique fractures and overlapping bone fragments (including bone grafts) is the recognition that compression can only be achieved by pressing the overlapping surfaces together,

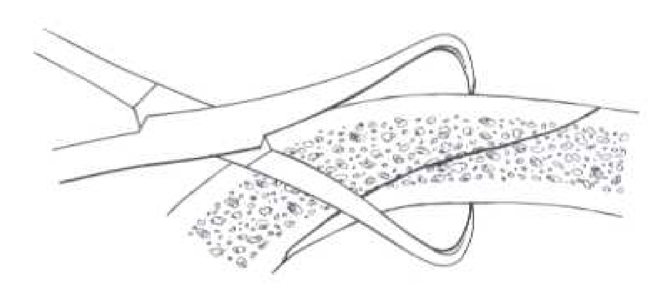


FIG. 2-30

not by trying to bring the fragments together along the axis of the bone.

NOTE: *Axial compression (as seen on the left) is only effective when the bone edges abut against each other. When they overlap, axial compression results in distraction. Therefore, overlapping fragments are compressed together using a lag screw technique.*

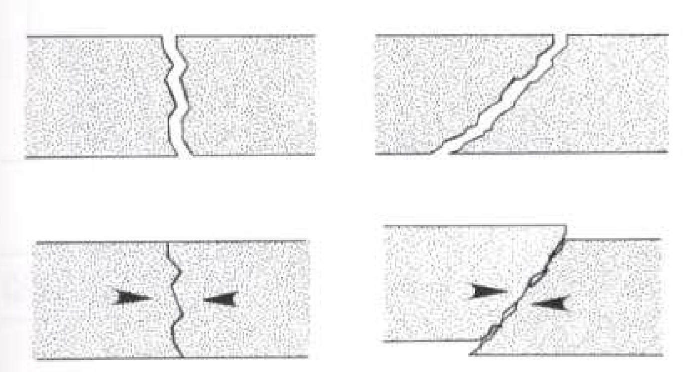


FIG. 2-31

Principles

The lag screw is a screw placed so that the thread will not catch in the first fragment, but it will catch and tighten securely in the second fragment. The first fragment thus acts as a washer. It is tightly compressed between the head of the screw and the second fragment.

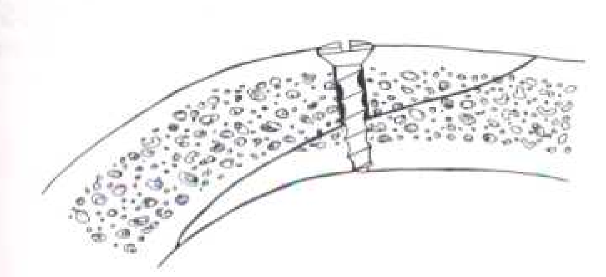


FIG. 2-32

If the screw thread were caught in the first fragment (acting like a nut instead of a washer), then tightening would stop when the screw head was tight against the first fragment. This would prevent further tightening between the two bone fragments (see the section on the positioning screw).

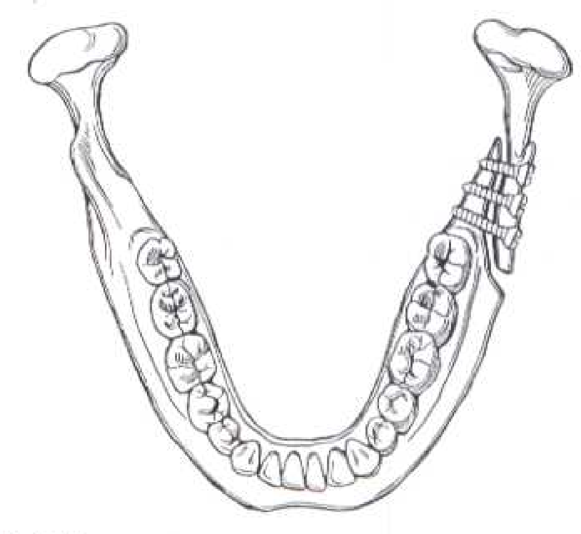


FIG. 2-33

For illustrative purposes, compare the two situations in Figs. 34 and 35.

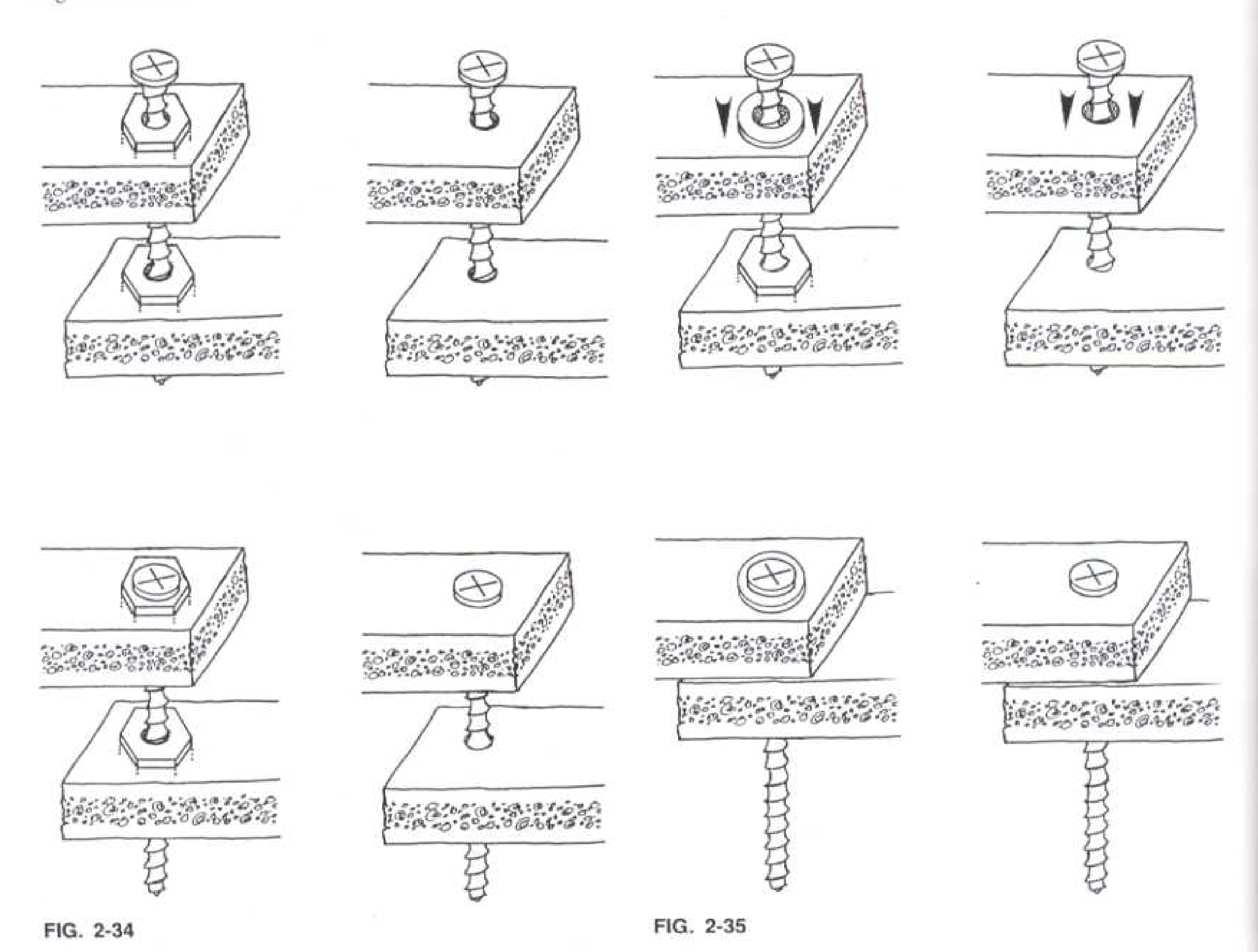


FIG. 2-34

FIG. 2-35

In Fig. 34, a screw is being tightened into two nuts, each of which is firmly held within a bone fragment; the nuts are thus prevented from turning (just as the anatomy prevents the pieces of bone from turning). As the screw is turned, the head gets closer to the first nut. Similarly, as the screw is turned in threaded holes in two pieces of bone, the head gets closer to the first piece of bone. Despite maximal tightening of the screws, because neither the nuts nor the bones can turn relative to each other, neither the nuts nor the bone fragments can be brought closer together.

In the real clinical situation, this inability to compress the fragments together is aggravated by the fact that, as the screw leaves the first fragment and enters the second fragment, it initially pushes the second fragment away, before the screw thread catches in the bone. The distance thereby created between the fragments cannot be narrowed as the screw is tightened. The screw therefore not only does not compress the fragments, it actually holds them apart. Several such screws will indeed stabilize the fragments and keep them from moving relative to each other, but they will also maintain a gap between the fragments. When this technique is used to repair a fracture, this may be enough of a change in the bony relationship to create a malocclusion (malunion). Furthermore, the lack of bone-to-bone contact may also increase the possibility of developing instability and nonunion.

When a lag screw is placed properly, the hole in the first fragment is overdrilled (i.e., it is the size of the thread rather than the size of the shaft of the screw) so that the thread will not catch in the bone. (The hole should not significantly exceed the size of the screw thread so that there is little lateral play between the screw and the bone.)

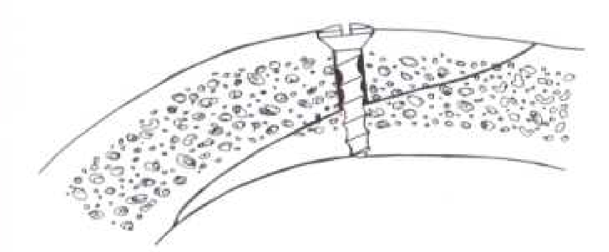


FIG. 2-36

The hole in the second fragment, however, is the size of the shaft of the screw; therefore, the screw thread will hold tightly in the second fragment. The first fragment thus behaves as a washer rather than as a nut. Although the nut and washer cannot turn relative to each other, the nut still moves closer to the washer as the screw is tightened (see Fig. 2-35).

As a result, tightening of the screw in the bone will result in compression of the first fragment between the screw head and the second fragment. Compression is thus accomplished. A second and third screw placed using the same technique will complete the stabilization of the fracture fragments.

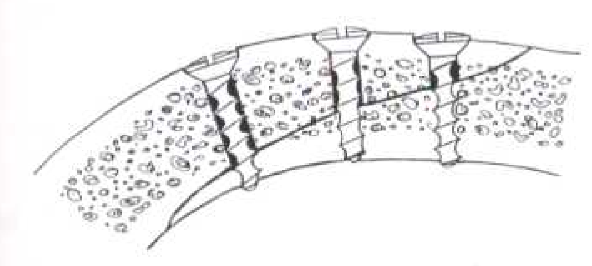


FIG. 2-37

Technique

The fracture is carefully reduced, and the fragments to be compressed are carefully aligned and positioned. The overlapping bone fragments are then compressed together by using a bone-holding clamp or a modified towel clip with a long ratchet.

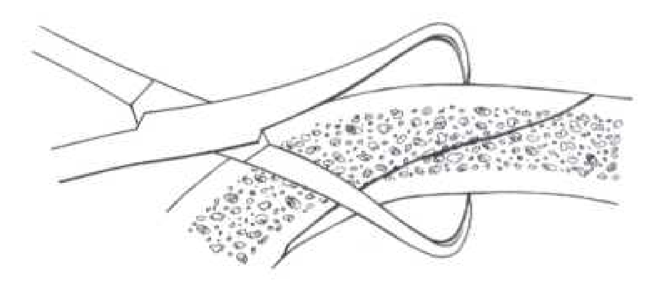


FIG. 2-38

The drill is positioned so that the final hole will pass securely through both fragments. For maximum stability of lag screw fixation, it has been found that a certain angle of screw placement relative to the bone surface and to the fracture direction is considered ideal. Although this is not believed by the authors to be a critical issue, it is shown here for instructive purposes. (Many surgeons place lag screws approximately perpendicular to the fracture. Although not ideal, this does seem to work effectively in most situations.)

The ideal direction is found by drawing a line perpendicular to the fracture and a line perpendicular to the bone surface. A line is now drawn that bisects the angle formed by the intersection of these two lines. This is the ideal direction for placement of the lag screw.

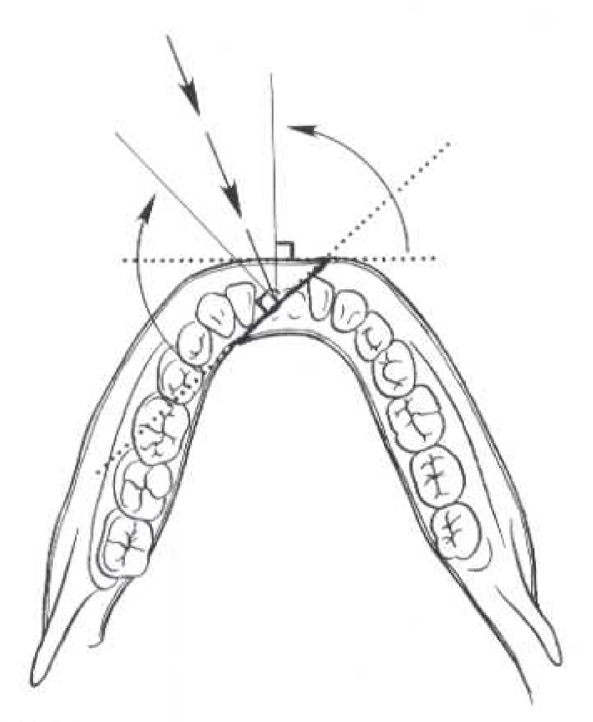


FIG. 2-39

Note that, in most situations, this line will be close to perpendicular to the fracture line. This probably explains why screw placement perpendicular to the fracture line usually works.

The first hole should be the size of the screw thread. (Thus, if a 2.7-mm screw is used, the most common size for mandibular repair, a 2.7-mm drill bit is used.) Using a drill guide to stabilize the drill bit, the first cortex is drilled, taking care not to proceed into the second fragment. This first hole is the "gliding" hole.

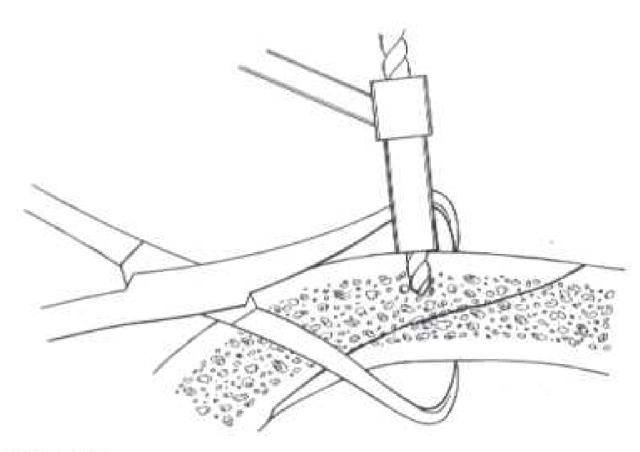


FIG. 2-40

When available, a drill guide designed specifically for lag screw placement is used. This guide fits into the gliding hole and stabilizes the smaller drill bit. The smaller drill bit (the size of the screw shaft) is now used to drill the hole in the second fragment.

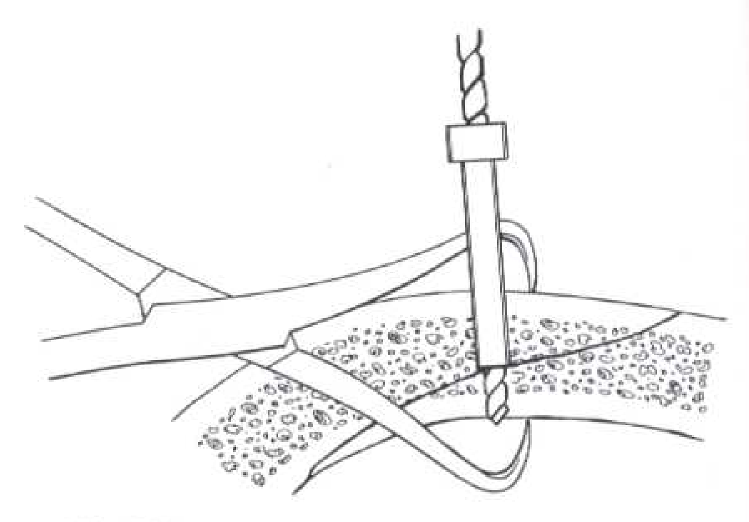


FIG. 2-41

A countersink is used to enlarge the hole in the first cortex for better seating of the screw head. This results in a broader surface area of contact between the screw head and the bone, which results in a more even distribution of pressure on the bone, a decreased likelihood of shattering the cortex, and a less prominent profile of the screw head over the bone.

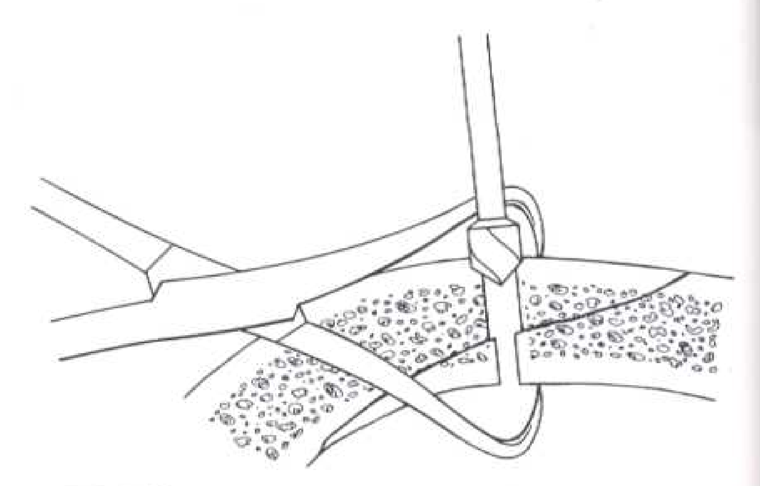


FIG. 2-42

Careful measurement of the depth of this hole is essential, making sure to catch both fragments completely with the depth gauge. When a system requiring tapping is used, a tap the size of the screw thread is used. Note that only the hole in the second fragment will be tapped. The tap should glide through the first fragment. The appropriate length screw is selected. This screw should glide through the first cortex, and the thread should catch in the second cortex. Tightening of this screw should compress the bone fragments together, thereby stabilizing the fracture.

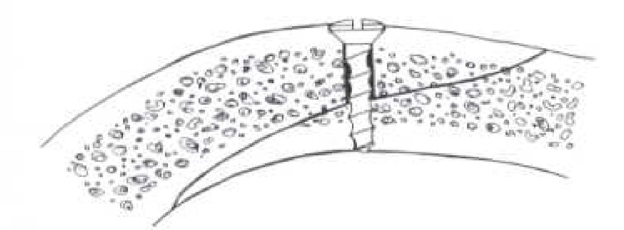


FIG. 2-43

Despite excellent compression, rotation is still possible around a single lag screw. At least one more lag screw must be placed across an oblique fracture if these screws are the only means of fixation. Although two lag screws may be adequate, three are preferable.

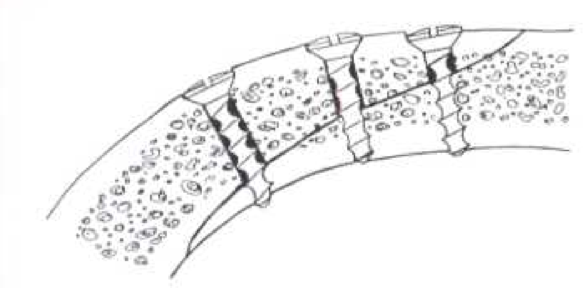


FIG. 2-44

Note that, when placing the second and third lag screws, it is critical to use care to avoid penetrating the second fragment with the larger drill bit. This is made more difficult by the excellent compression of the fragments achieved with the first lag screw. Great care and a sensitive touch are therefore of the utmost importance. After all lag screws have been placed, repair is complete.

LAG SCREW THROUGH A PLATE

If not enough overlapping bone is available for several lag screws or if a stronger fixation is needed as a result of the thinness of the bone or the surgeon's preference, lag screw and plating techniques can be combined.

A lag screw may be placed through the two fragments adjacent to the plate, or lag screws may be placed through the plate. In either case, all screws passing through both overlapping fragments are placed as lag screws (not positioning screws), and all other screws through the plate (i.e., those through only one of the fragments) are placed neutrally (not eccentrically).

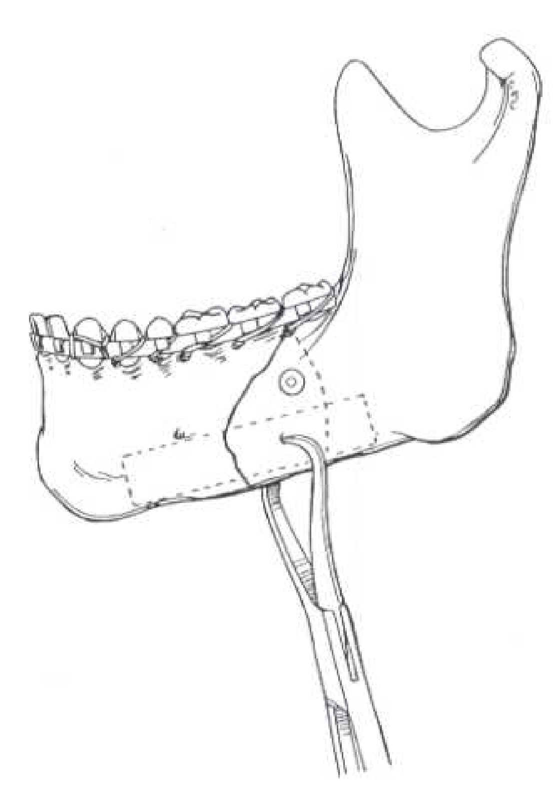


FIG. 2-45

The plate is bent to shape and positioned across the fracture. Any plate holes that overlap both fragments are identified for lag screw placement. The lag screw(s) is(are) placed first using the same lag screw technique described earlier, except that the hole is not countersunk because the head of the screw will rest in the plate hole. The screw is directed so that it will cross the two fragments and pull them together, regardless of the angulation of the screw relative to the plate.

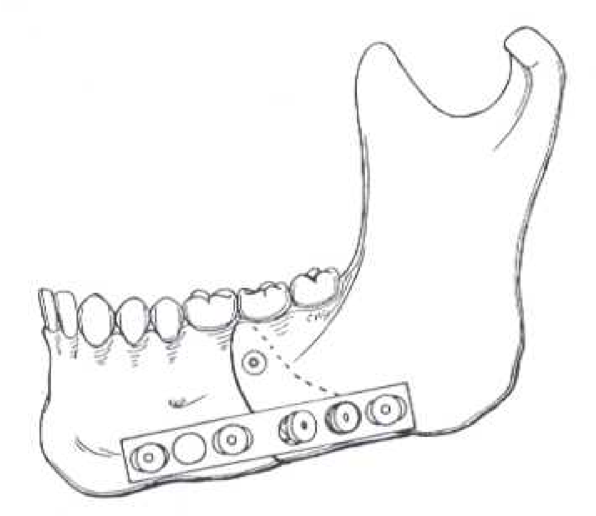


FIG. 2-46

Only after all lag screws that can be placed have been tightened can the remaining screws be placed. These are drilled neutrally, perpendicular to the plate and bone.

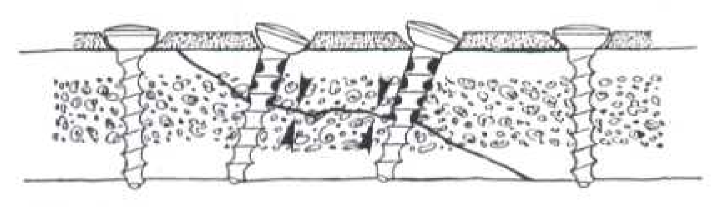


FIG. 2-47

POSITIONING SCREW

A positioning screw is used when overlapping fragments are not to be compressed, i.e., they are to be stabilized in a fixed relationship. (This is used mainly to fix the sagittal split osteotomy without compression to avoid altering the condylar position.)

It is the exact opposite of the lag screw. In fact, it is the result obtained when a lag screw is placed improperly so that the first hole is a threaded instead of a gliding hole.

The bone fragments are held in the desired position. Using a drill guide when possible, the appropriate drill bit, i.e., the size of the screw shaft, is positioned so that the hole will pass through both fragments. The hole is drilled through both fragments using irrigation to cool the bone. The depth of the hole is measured, being sure to catch the second fragment with the depth gauge. When necessary, both holes are tapped with a hand tap the size of the screw thread. The outer hole is countersunk to allow for better seating of the screw head.

The appropriate-length screw is passed through both fragments and tightened. Unlike the lag screw, tightening the screw will not compress the fragments together. Instead, it will maintain the preexisting distance between them, thus the term positioning screw.



FIG. 2-48

A second (and preferably a third) positioning screw is placed for stabilization of the fragments.

"EMERGENCY" SCREW

The term emergency screw refers to the screw used when a hole in the bone strips. This is a screw with a head and a shaft that are the same as those of the screw that did not hold (so that it will fit appropriately), but it has a wider thread. It is always a self-tapping screw.

When a screw that is placed in a hole continues to turn and will not tighten, it must be removed. A loose screw should not be left in place because it provides no stabilization and it may be a source of infection. The failed screw is discarded, and an emergency screw of the same length is selected and placed in the hole. It is carefully screwed in and tightened.

If this screw strips also, then the hole should be left empty. (If there are not enough stabilization points without this screw, do not leave the plate in place. It must be repositioned or replaced. Leaving a plate with an inadequate number of fixation points violates biomechanical principles, does not provide rigid fixation, and increases the risk of infection and failure.)

CHAPTER 4

Principles of Plate (and Screw) Application

NOTE: *Differentiation between a miniplate and a compression plate is a misnomer, and the use of these terms is often confusing. The compression plate is differentiated from a plate that can only be applied neutrally, i.e., a neutral-only plate has no compression holes, and it can only be applied neutrally.*

The term miniplate, on the other hand, refers to plate size; unfortunately, various-sized plates have been called miniplates, depending on the system being used. Most miniplates, however, are used with 2.0-mm screws. Note also that miniplates can be compression or neutral plates, as can larger and smaller plates.

The term miniplating technique, when used in reference to mandible fractures, generally refers to the use of neutral miniplates with 2.0-mm monocortical screws along the ideal line of osteosynthesis as developed by Champy (see the section on distracting/compression forces). This refers primarily to the technique and approach rather than to the specific plates used.

GENERAL PRINCIPLES

For the application of most plates, the following principles are important:

1. The bone to be plated is positioned and stabilized as much as possible prior to beginning plate application.

2. A template is generally used. One that matches the dimensions and shape of the plate to be applied is positioned on the bones in the position in which the plate is to be placed. It is important that the fragments be reduced and held in position prior to attempting to position the template. Do not screw a template in as a fixation device. The template is easily bent by hand to match the bony contours.

3. The template is removed from the wound. The plate is now bent to match the template as closely as possible. (Facility with bending takes practice and usually becomes easier to accomplish as experience is gained. Note the use of inserts when bending the titanium hollow screw reconstruction plate [THRP], which is discussed later.) Note that repeated bending weakens the metal and may lead to plate fracture (particularly when using titanium). If multiple bends have been required, it may be wise to discard the plate and bend another for implantation.

4. The plate is then positioned on the bone where it is to be implanted. If the bend does not conform well to the bone, then final bending adjustments must be carried out at this time.

5. The bending complete, the plate is positioned and stabilized as well as possible, sometimes with a modified towel clip and sometimes with plate-holding forceps or other device as desired.

6. When available, a drill guide is positioned in the plate hole, and the drill is placed in it so that the hole will be perpendicular to the bony surface.

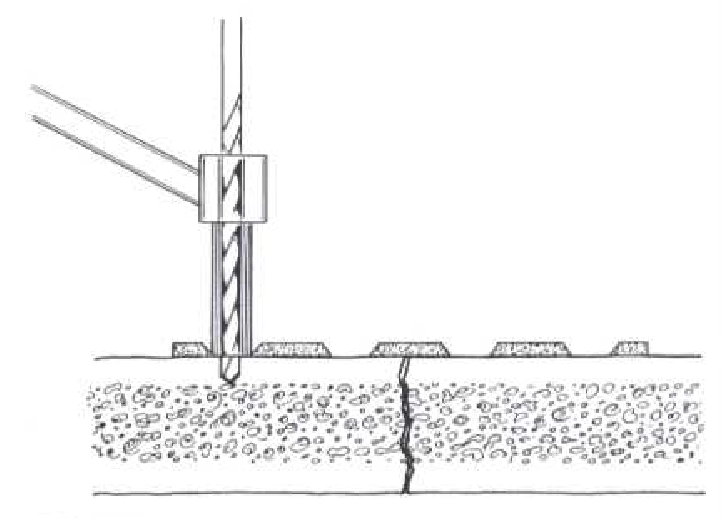


FIG. 2-49

The appropriate drill bit must be used for the size of the screw to be implanted. The drill bit approximates the size of the shaft of the screw not the thread size. (Note that most screws are named by thread size not by shaft size.)

7. Drilling is carried out, taking care to minimize drill wobble as much as possible. This is important to maximize the screw-holding power of the bone, which is markedly decreased if the hole is funnel shaped instead of cylindrical.

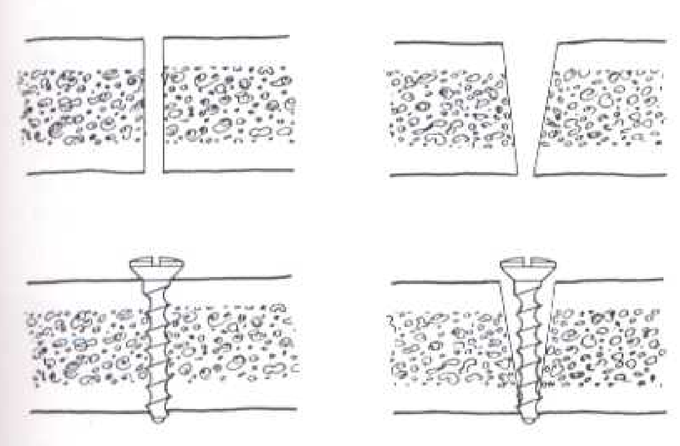


FIG. 2-50

Drilling is performed at low to medium speed, without pressure and with constant cool irrigation to minimize damage to the bone. (Bone necrosis will lead to screw loosening and a failure of the fixation.)

   a. For monocortical screw placement, great care must be taken to stop drilling the moment that resistance decreases, indicating that the drill has passed through the first cortex.

   b. For bicortical screw placement, drilling is continued through the second cortex.

8. A depth gauge is now used to measure the depth of the hole for screw selection. The depth gauge has a lip on the end that catches the opposite end of the bone. After this has been accomplished, the sleeve on the gauge is advanced onto the plate and bone, and the depth of the hole is indicated by the ruler on the shaft of the instrument where the sleeve ends. It is important when using bicortical screws to be certain that the gauge has caught the second cortex and not the first.

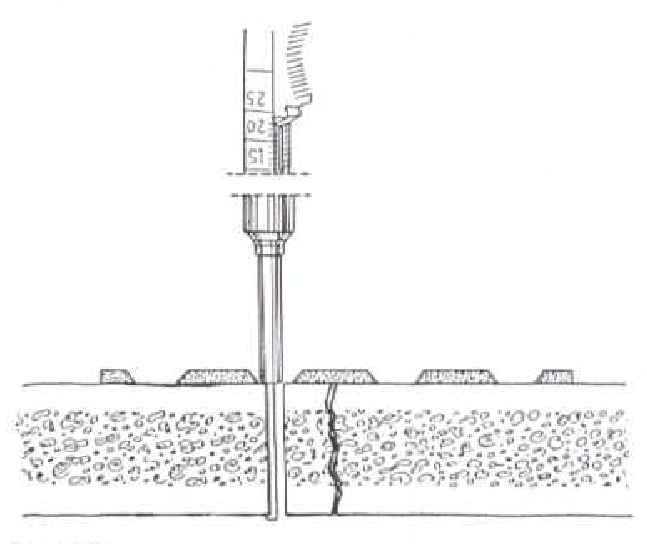


FIG. 2-51

9. At this point, if self-tapping screws are to be placed, proceed to the next step. Otherwise, the hole is now tapped with a tap that is the size of the screw thread. Great care must be taken to tap in the same direction as the hole to avoid damage to the hole. The tap is turned clockwise until the hole is tapped, and then it is turned counterclockwise to remove it, always taking care to avoid any pull, push, or angulation that could damage the threads and the hole.

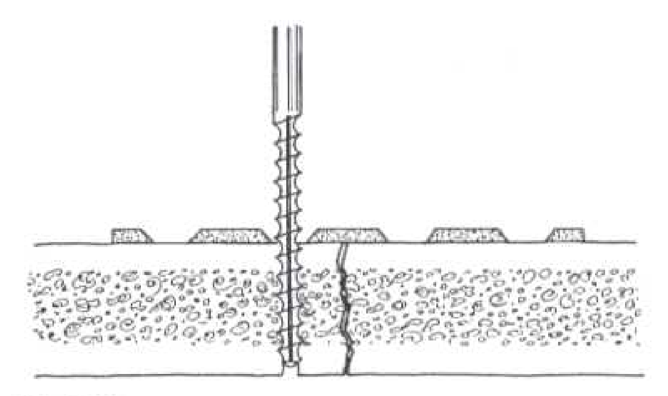


FIG. 2-52

NOTE: *The depth gauge should not be reinserted after the hole has been tapped because the depth gauge may damage the threads that the tap cut into the bone.*

10. The appropriate length screw is now selected from the set and positioned for placement. Various devices hold the screws:

    a. A sleeve on the screwdriver may hold the screw in position for placement. Generally, these devices will grab the screw head best while the screw is in the tray in the set.

    b. Screw-holding forceps can be used to position and hold the screw. When using these, the screw should be grasped immediately below the head to avoid damage to its thread.

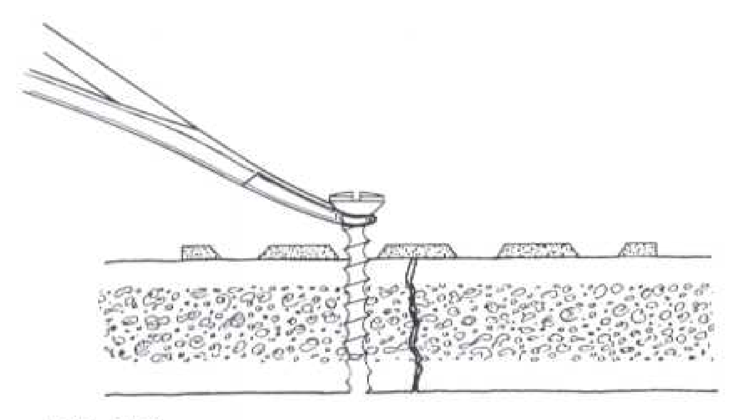


FIG. 2-53

For the same reason, i.e., to avoid thread damage, grasping the screw with a clamp is avoided.

11. The screw is screwed into the hole. When placing neutral screws, each is tightened before the next hole is drilled. For compression screws, see below. (For the THRP, expansion bolts are placed after the screws are tightened (discussed later).)

PLACING A NEUTRAL (NONCOMPRESSION) PLATE AND SCREWS

A neutral screw serves to hold a fixation plate firmly to the underlying bone. When all screws in a plate are neutral, the plate serves as a fixation device that holds the pieces of bone together by fixing the fragments to the plate, which serves as a rigid bar and thereby imparts its strength to the fixation. The fixation is only as strong as (1) the strength of the fixation technique, i.e., the hold of the screws in the bone, and (2) the rigidity (strength) of the plate itself. When used along with compression screws, the neutral screws are used to reinforce the fixation imparted by compression and by the plate.

The key to placement of a neutral screw is to avoid any interaction between the screw head and the plate, other than the final seating of the screw head in the plate hole. This requires central positioning of the drill hole in the plate hole. When the plate hole is round and designed to be neutral, this is a simple matter. When placing a neutral screw in an elliptical hole, great care must be taken to position the drill hole in the center of the plate hole. When available (standard in some systems), specially designed drill guides help ensure the proper positioning of the drill hole.

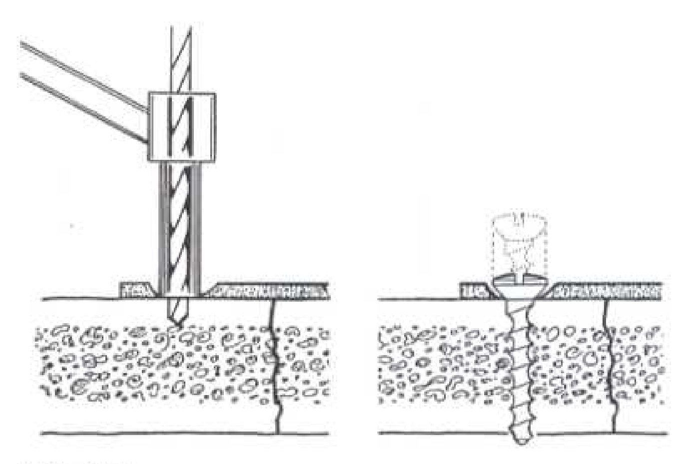


FIG. 2-54

PLACING A COMPRESSION PLATE AND SCREWS

Principles

NOTE: *Compression adds greater strength to the fixation by increasing the frictional forces across the fracture and thereby increasing the strength of the bridging that is contributed by the underlying bone.*

The compression plate is designed to compress fracture fragments together in a predictable way. Compression is brought about by a planned interaction between the plate and the screw. If the head of the screw is positioned so that it overlaps a beveled ledge in the plate, tightening of the screw will force the plate and screw to move relative to each other because two noncompressible objects cannot occupy the same space at the same time. The screw will slide along the beveled edge of the plate hole, and the plate will thus also move relative to the screw (in the opposite direction).

If the screw has been screwed into a bone fragment, the bone and the screw will move as a unit (which can be called a "screw—bone unit"), thereby creating a predictable relative movement between the plate and the bone.

When the bone is apposed against another piece of bone, as is the case in a fracture, a screw lodged against a hole in the same plate that fixes the plate to the second piece of bone prevents the second piece from moving away, thereby resulting in compression. This is generally accomplished in the following two ways in the fixation systems currently in use.

1. Some plates are designed with two compression holes on one side and two neutral holes on the other.



FIG. 2-55

After reducing the fracture and bending the plate, the two neutral screws are placed through the neutral holes into one of the fragments. The compression screws are then placed one at a time into the other fragment.

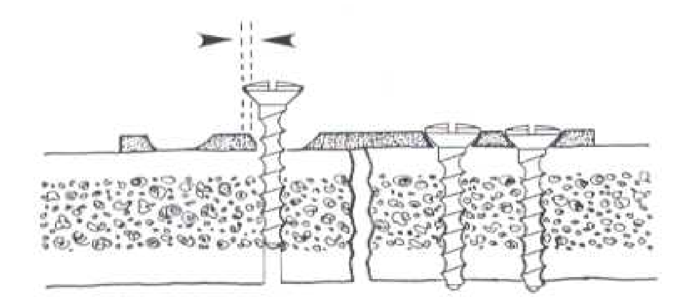


FIG. 2-56

After the head of the screw makes contact with the plate, continued tightening displaces the plate and screw head in opposite directions relative to each other. The screw is pushed toward the other fragment, bringing the bone with it, because it has formed a screw—bone unit. The other bone fragment cannot move away because the neutral screws that form a screw—bone unit with it are held in the plate.

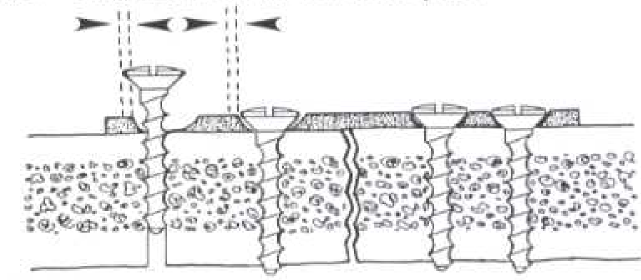


FIG. 2-57

A second compression screw adds additional compression across the fracture line.

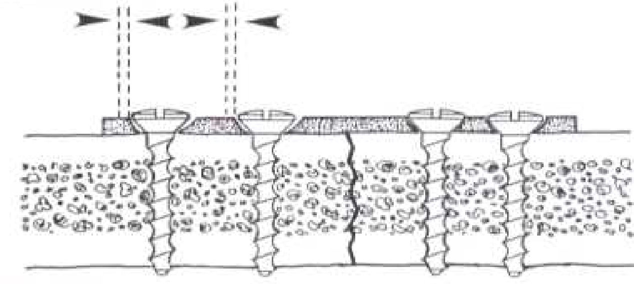


FIG. 2-58

Note that each hole is drilled and a screw is placed prior to drilling the next hole because motion created by each screw placement could alter the relationship of the next hole to the bone. A prematurely drilled series of holes may turn out to be slightly mispositioned, resulting in increased stress on the screws and therefore an increased risk of failure.

2. Other plates are designed with holes that can be used to apply compression on both sides of a fracture. These are of two types.

1. Some have holes on each side of the plate that are designed for compression and holes that are designed to be neutral (e.g., Howmedica Luhr system). The compression holes are used first to accomplish compression across the fracture. Neutral screws are then placed in the neutral holes to add additional support and stability to the fixation.
2. Some are designed with elliptical holes that can be used for either compression screws or neutral screws, depending on the placement of the drill hole relative to the plate hole. That is, if the hole is drilled so that the screw head overlaps the plate, tightening will result in compression.

However, if the screw is centered in the hole so that there is no overlap, no movement between the screw and the plate will occur. Thus, a neutral screw is placed. This plate gives the surgeon the option of using any hole for placement of a neutral screw or a compression screw.

It should be apparent that proper utilization of a compression plate requires careful attention to technique and particularly accurate screw positioning.

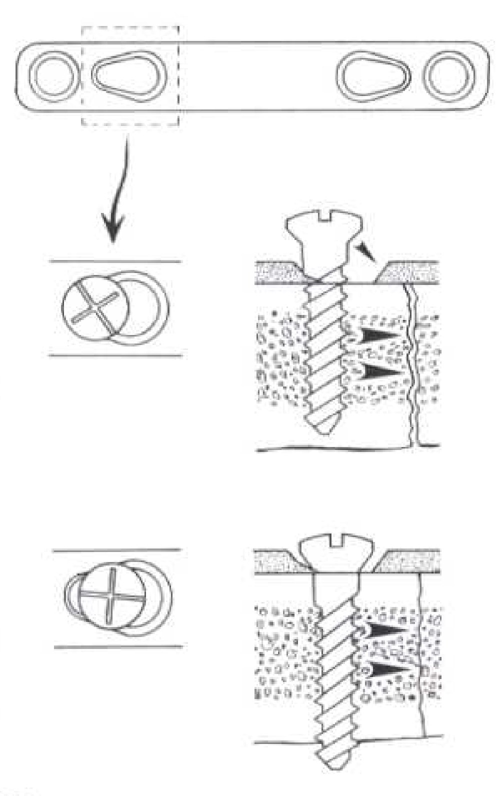


FIG. 2-59

Technique

When two opposing compression screws will be used, the plate has been bent, and it is held in position on the bone. The drill is positioned in the first hole so that the hole is eccentrically placed in the plate hole away from the fracture site (the site to be compressed), i.e., the hole is drilled in the bone so that the shaft of the screw is near the edge of the plate hole (away from the fracture), and the head of the screw overlaps a portion of the plate itself.

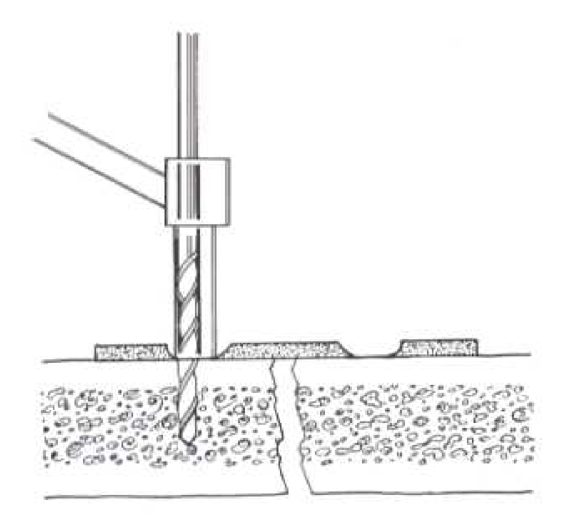


FIG. 2-60A

Screw placement is carried out, but tightening is stopped just before the screw head makes contact with the plate. The screw head must overlap the plate. (Compression screws must be bicortical.)

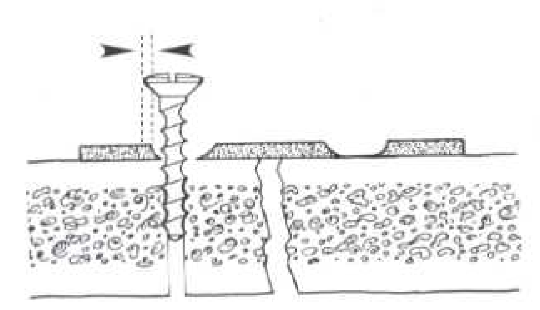


FIG. 2-60B

The second screw hole is drilled in the opposing fragment, similarly placing it eccentrically (away from the fracture site).

The hole is drilled, measured, and tapped (when appropriate), and the screw is placed. This screw head similarly overlaps the plate hole;

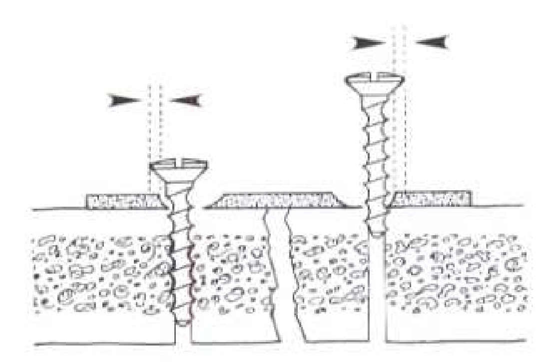


FIG. 2-60C

therefore, tightening of this screw pushes it toward the fracture site (relative to the plate). The screw—bone unit thus moves toward the other fragment.

The first screw is now tightened, adding additional compression across the fracture. Compression is now complete.

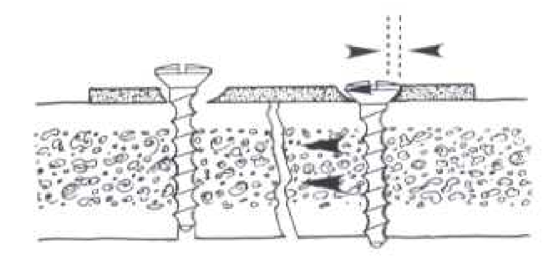


FIG. 2-60D

Additional bicortical screws are placed neutrally to add additional stability and support to the fixation.

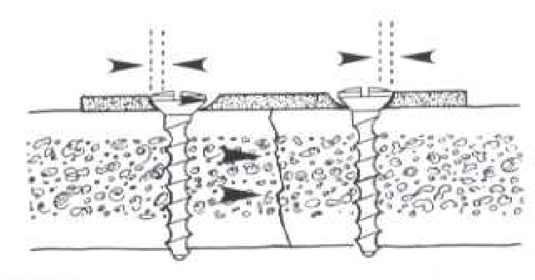


FIG. 2-60E

When compression screws are on the same side of the plate, neutral screws have already been applied in the opposite side of the plate, thus stabilizing the plate to this fragment.

The compression screw holes overly the remaining fragment. The first compression screw is now placed and tightened.

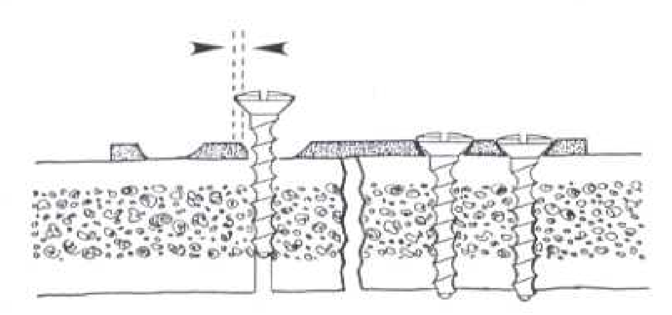


FIG. 2-61

Of course, this is positioned in the plate hole so that it is away from the fracture. Compression is created between the fragments by the interaction between the screw head and the plate.

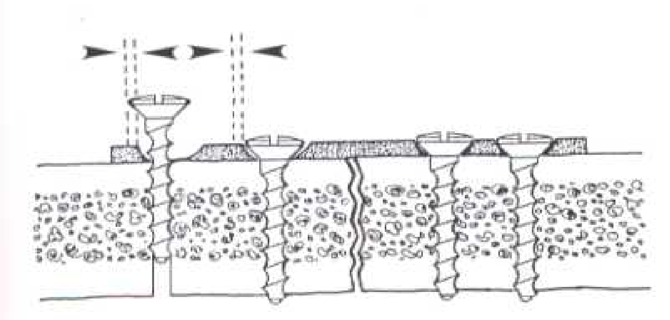


FIG. 2-62

The second compression screw is now placed (eccentrically, away from the fracture) and tightened, thus adding additional compression. When using a compression plate, all screws are placed bicortically.

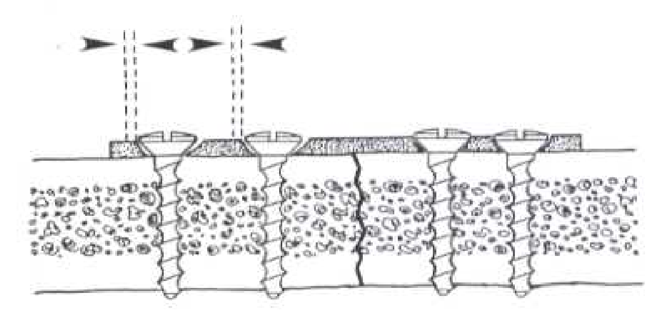


FIG. 2-63

USE OF THE EDCP

The EDCP is a special type of compression plate. The standard compression plate (sometimes called a dynamic compression plate or DCP) is designed so that the holes are horizontal; therefore, proper screw placement will generate axial compression forces, i.e., along the axis of the the plate.

The EDCP is designed with axial compression holes and angled or vertical compression holes. In the angled holes, overlapping the screw head and the plate results in an interaction between the screw and the plate, as occurs with any compression plate hole. However, because the direction of the hole is different from the axial compression holes, the direction of the forces generated is along the axis of the plate hole rather than along the axis of the plate itself.

Proper use of this plate is tricky and requires careful attention to the following principles and steps. The EDCP is designed to provide compression of the alveolar (traction) side of a mandibular fracture despite being positioned along the basal border (pressure side) of the mandible. It is specifically designed to allow for the use of a compression plate along the pressure side of a fracture in the absence of any form of tension band fixation of the traction side. It is recommended by the authors that this technique be used only when compression is desired in a situation in which tension banding cannot be accomplished. (Otherwise other techniques should be considered.)

The plate is designed so that eccentric placement of screws in axial holes provides axial compression; eccentric placement of screws in diagonal or vertical holes provides compression directed superiorly (toward the upper border of the fracture).

To accomplish this, two principles must be observed, and the following steps performed:

1. The upper (alveolar) border must be precompressed or held firmly together before any screws are placed.
2. The horizontal (axial) screws must be placed first!

This plate functions as follows:

1. The alveolar border is precompressed using towel clips or mandibular reduction forceps with side rollers.

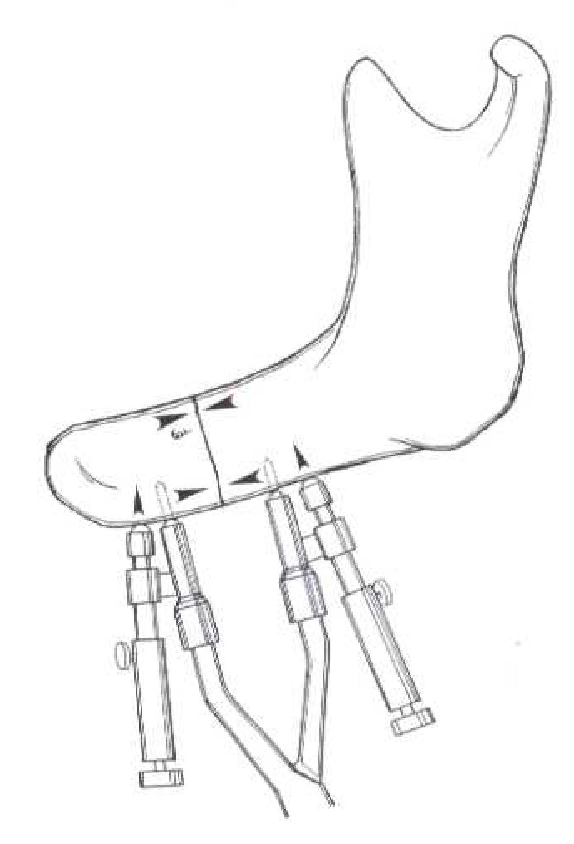


FIG. 2-64

2. The axial compression screws (only two) are placed and tightened sequentially as in standard compression plate application. This creates axial compression.

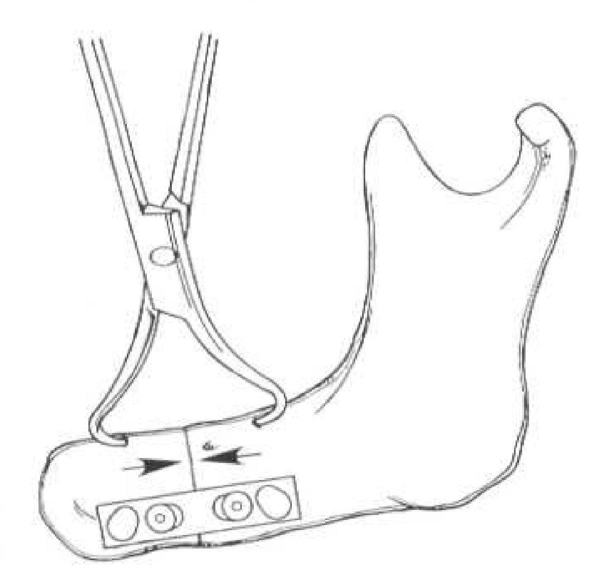


FIG. 2-65

a. If the alveolar border is not held together in some fashion (e.g., bone clamp, modified towel clip, or reduction pliers with rollers), then the alveolar border will be distracted. This will result in a poor fixation.

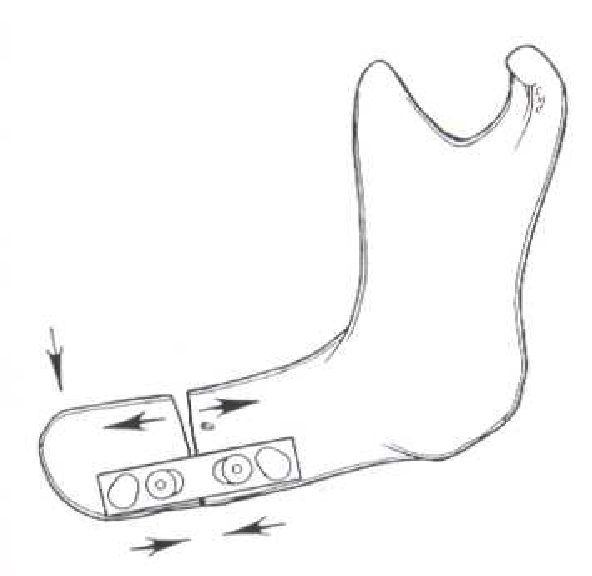


FIG. 2-66

b. If a bone-holding device (e.g., clamp, clip, or pliers with rollers) holds the alveolar border together, then it serves as a temporary tension band, and the compressive forces are distributed along the fracture. (If the device were removed at this point, the alveolar border of the fracture would gap.)

3. The more vertically directed screws are now placed (after the two (and only two) horizontal screws).

These are positioned inferiorly in the plate holes so that the screw head—plate interaction will push the screw (and the bone with it) superiorly. Because the first screw in each fragment is already holding the bone to the plate, the bone cannot move straight up, it can only rotate around the first screw, thereby closing the alveolar border of the fracture and applying compression to this area.

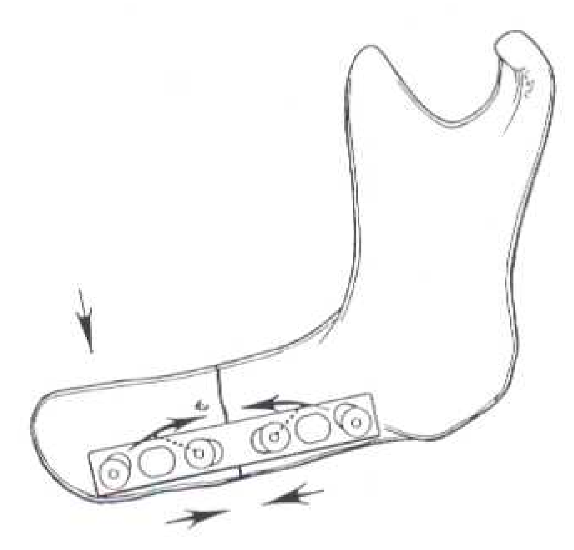


FIG. 2-67

When more than four holes are present in the plate, additional screws are placed neutrally.

USE OF THE RECONSTRUCTION PLATE

A reconstruction plate is different from either a standard neutral plate or a compression plate in that it is designed specifically to be able to bridge gaps in bone. Standard (nonreconstruction) plates are used to repair fractures and hold fragments together. The continuity and, thus, the integrity of the repair is provided by the bone that is being held together. The plate adds stability, but the bone provides the underlying supporting framework. On the other hand, the reconstruction plate is designed to be able to replace the integrity of the underlying bone. It can be used in the following situations:

1. There is bone missing.
2. There is severe comminution so that the bone is functionally absent, even though the fragments are present.
3. The bone is exceedingly weak, as is the case in an atrophic edentulous mandible.
4. Another fixation technique seems to be difficult or potentially unsatisfactory. Because a reconstruction plate can serve to replace a defect, it can certainly provide the strength to be a fall-back technique when another technique seems to provide a tenuous repair for any reason. Like standard plates, the holes in a reconstruction plate can be designed as neutral holes, compression holes, or elliptical holes, which can be used either way. Bending and screw application are the same as described earlier. The actual technique of application is fairly straightforward and is discussed under the specific anatomical areas involved.

USE OF THE THRP

The THRP is a mandibular reconstruction plate that is designed to provide additional stability by adding two major features not available with other mandibular reconstruction plates (MRPs).

1. The head of the screw is expandable. It fits tightly and precisely in the plate hole. An expansion bolt is then screwed into the head of the screw. This expands the slotted screw head, thereby fixing the head of the screw to the plate, which holds the screw and keeps it stable if there is transient bone resorption and loosening of the screw in the bone. So long as some screws remain stable in the bone, the remaining screws will remain stable in the plate, thereby providing time for bone healing and restabilization of the screws in the bone. This plate thus provides all the potential benefits of an external fixator and the additional benefits of shorter lever arms and internal fixation.
2. The hollow screw design allows for ingrowth of bone into the screw shafts. This increases the stability of the fixation between the screws and the bone. Plate application is similar to other MRPs, except for certain unique aspects (marked with asterisks).

   a. After the template has been bent, the appropriate length plate is selected.

   *b. Inserts are then placed in the plate holes so that the holes are not distorted during the bending process.

NOTE: *This step is required only for the first generation THRP system made by Synthes. In the THRP-2 system manufactured by Leibinger, the need for this step has been obviated by reinforcing the plate holes so that they will not be distorted by normal bending.*

   c. Bending is completed using various bending devices as needed.

   *d. The inserts are removed using a hole-punch-like device. (Only with the original THRP, not THRP-2.)

   *e. A reamer is used to make certain that the plate holes will allow seating of the expendable screw heads.

   f. Each hole is drilled (sequentially), measured, and tapped. The appropriate length screw is then applied and tightened.

   *g. After all screws have been placed, expansion bolts are screwed into each screw head to expand the screw head and thereby fix the screw to the plate.

UNIT III

Surgical Approaches

UNIT OUTLINE

CHAPTER 1

Mandible

INTRAORAL

Symphysis and Parasymphysis

The oral cavity is thoroughly cleansed with a preparation solution of the surgeon's preference, such as chlorhexidine gluconate mouth rinse. The mucosa at the proposed incision site may be injected with a vasoconstricting agent if the surgeon prefers. An incision is made from canine to canine in the mental region. The first incision is made through the mucosa only, everting the lower lip with retractors placed on each side of the midline. The incision is placed at least 5 mm away from the mucosal gingival junction and is carried only through the mucosa. The scalpel blade is held at right angles to the underlying mucosa. The second incision is then made through the first at right angles to the underlying bone and is carried down through the submucosa, musculature attachments, and periosteum.

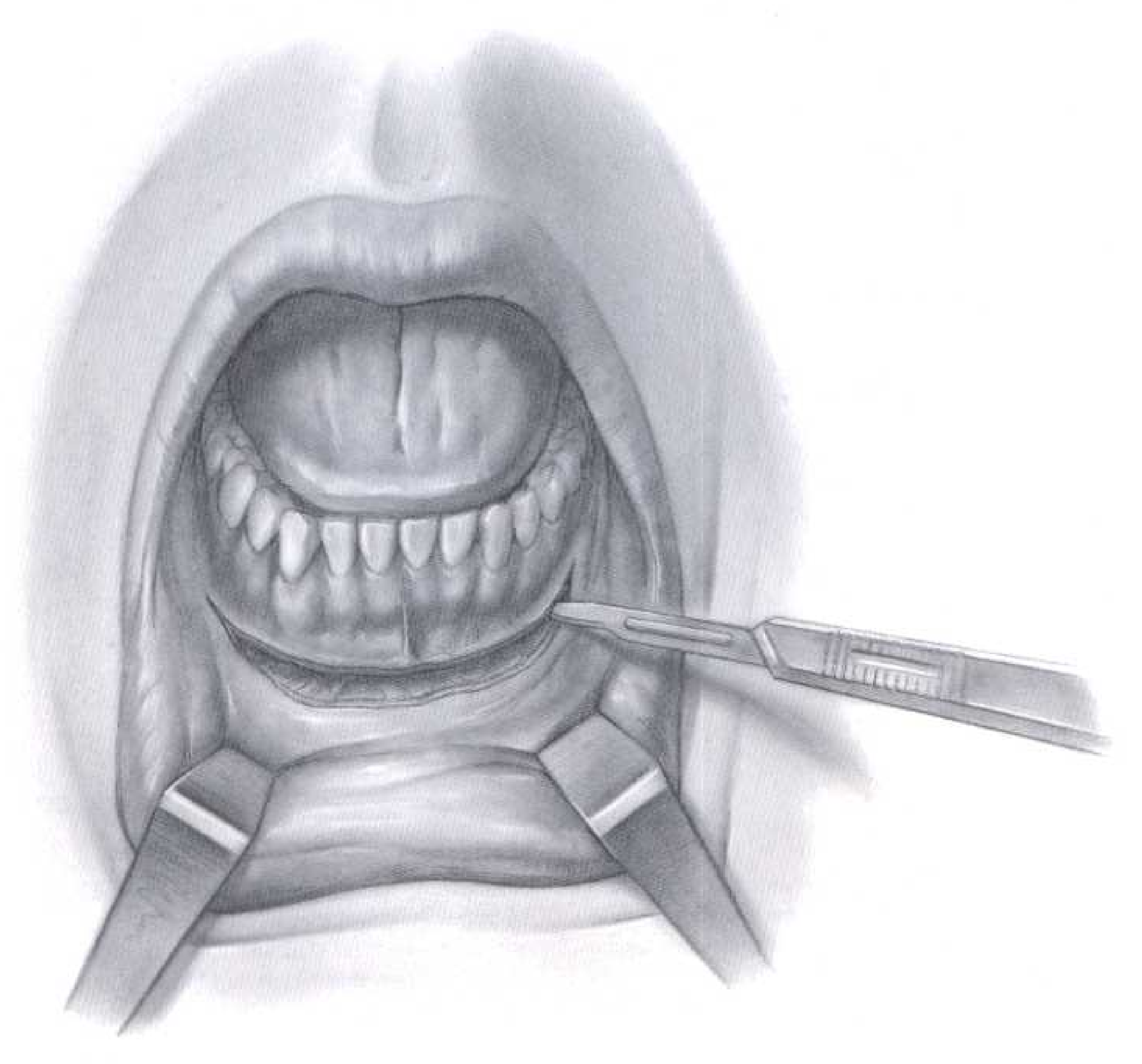


FIG. 3-1

Laterally, care must be taken to avoid the mental nerve, which is identified during the subperiosteal dissection. While grasping the inferior part of the mentum in one hand for support, the surgeon uses a periosteal elevator to elevate periosteum and overlying soft tissues of the bone.



FIG. 3-2

During the course of the elevation, the fracture site is identified as are the tooth roots of the anterior teeth. At the most lateral portion of the incision, the mental foramen and branches of this nerve can be readily seen and preserved during the dissection. The mental foramen can be identified with its exiting nerve, thereby preserving the neurovascular bundle. The dissection is carried inferiorly to allow adequate application of the fixation system, but it is not so extensive that it would elevate areas of the periosteum not essential to the application of the plate.



FIG. 3-3

Following plate application, the wound is then irrigated, and the closure is accomplished in two layers. A suture of the surgeon's choice is used. The first layer begins at the midline and works laterally first to one side and then to the other. The first layer is usually a running horizontal mattress suture. Following this, the closure of the second layer is performed, closing the everted edges of the mucosa in a simple continuous fashion. Adhesive elastic bandages may be applied in the chin region in the area of the labio mental fold above and on the inferior part of the mentum below to help eliminate dead space, or a 19 gauge butterfly drain may be brought out through the skin under the mandible and placed into a vacuum tube for suction.

Mandibular Body

The incision is made in the area of the fracture site through the mucosa making sure that the incision is perpendicular to the mucosa. By keeping the incision approximately 5 mm from the mucosa gingival junction, the second (deeper) incision usually incises the periosteum above the region of the mental nerve.

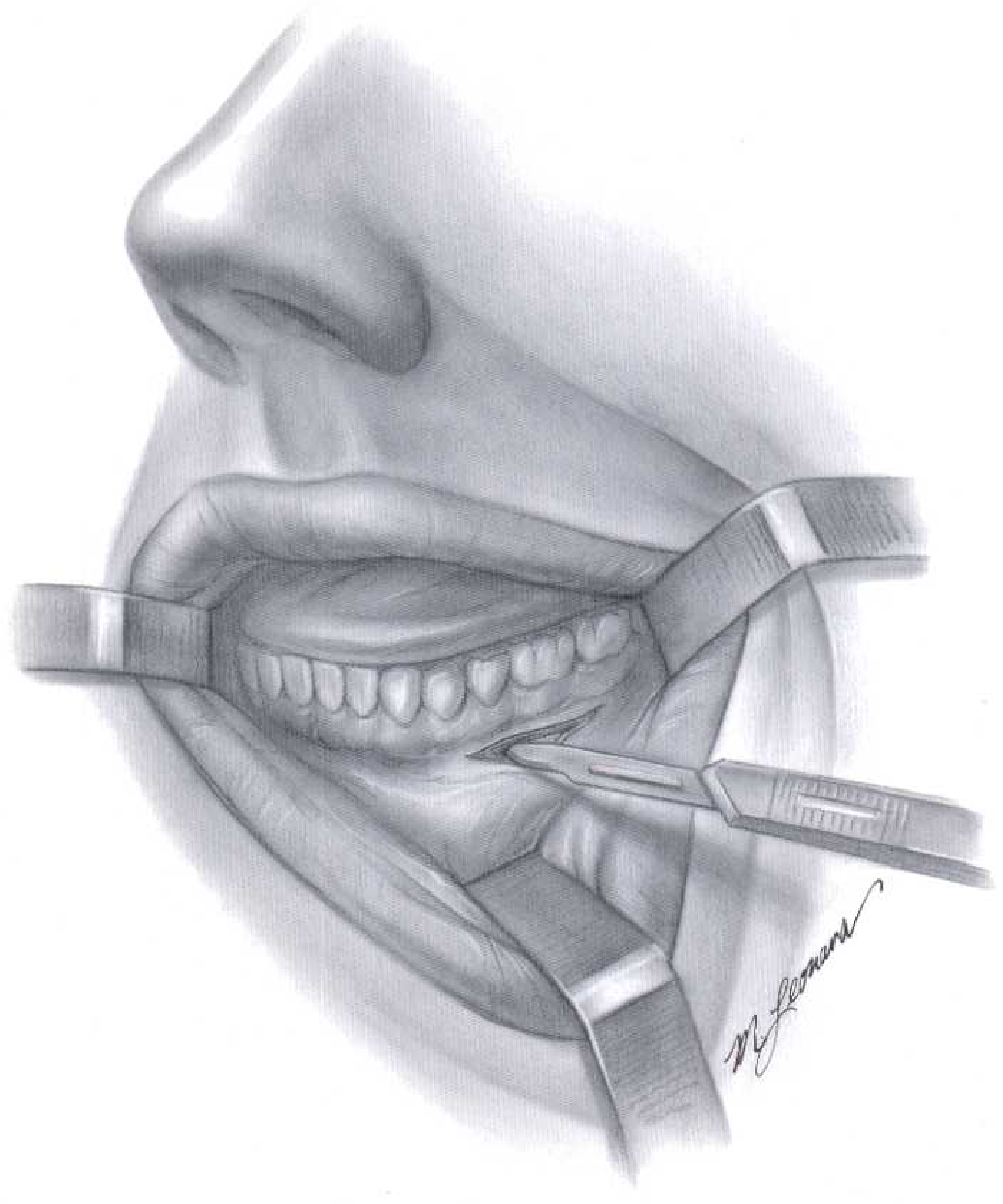


FIG. 3-4

However, if there is concern about injury to the nerve, the deeper incision may be started in the posterior body in the area of the first and second molar and second bicuspid. Periosteal elevation begins in this area. Then, under direct visualization, the elevation is carried out from posterior to anterior until the mental nerve is identified. The incision may then be safely completed in the area of the canine and first bicuspid.

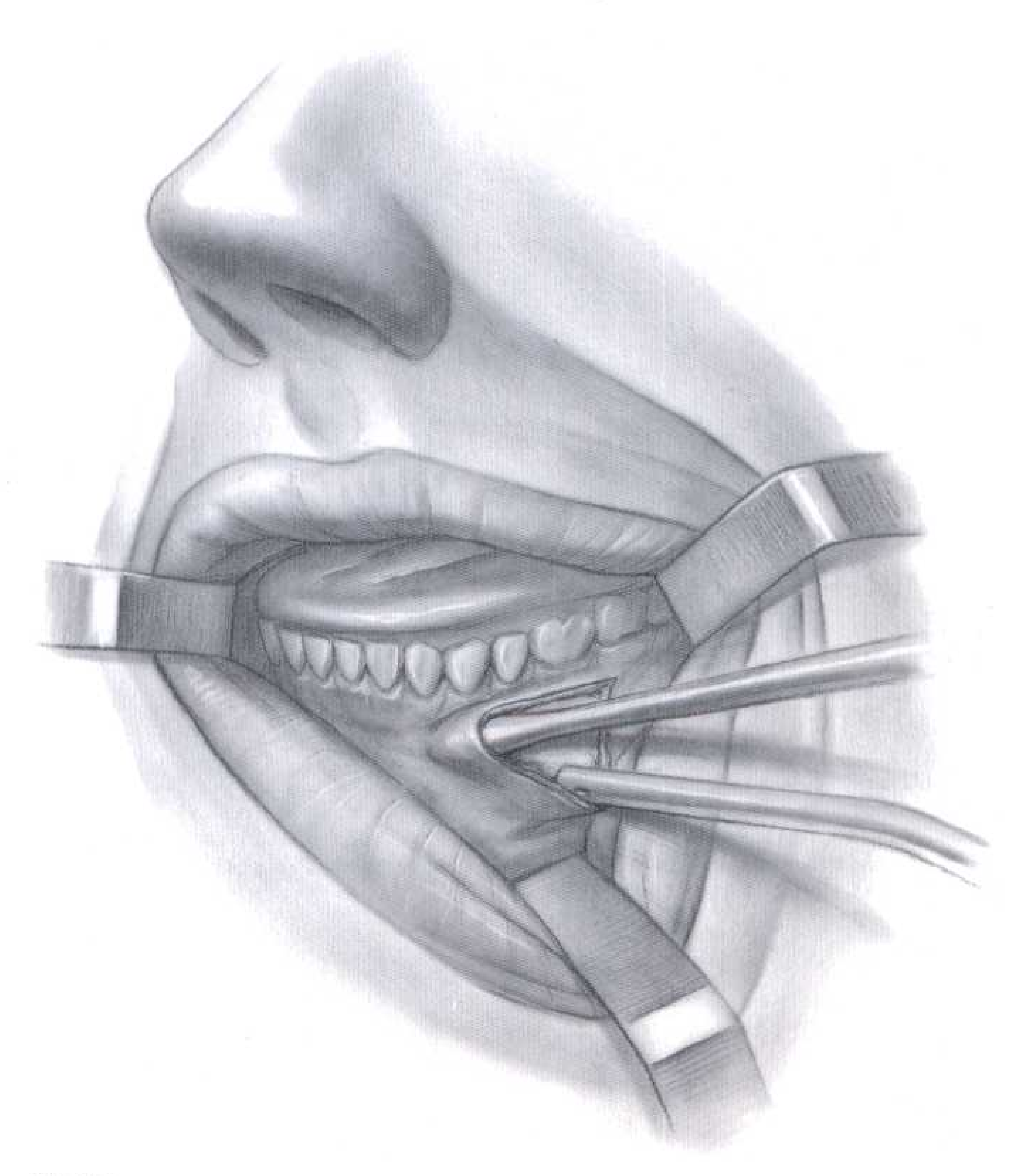


FIG. 3-5

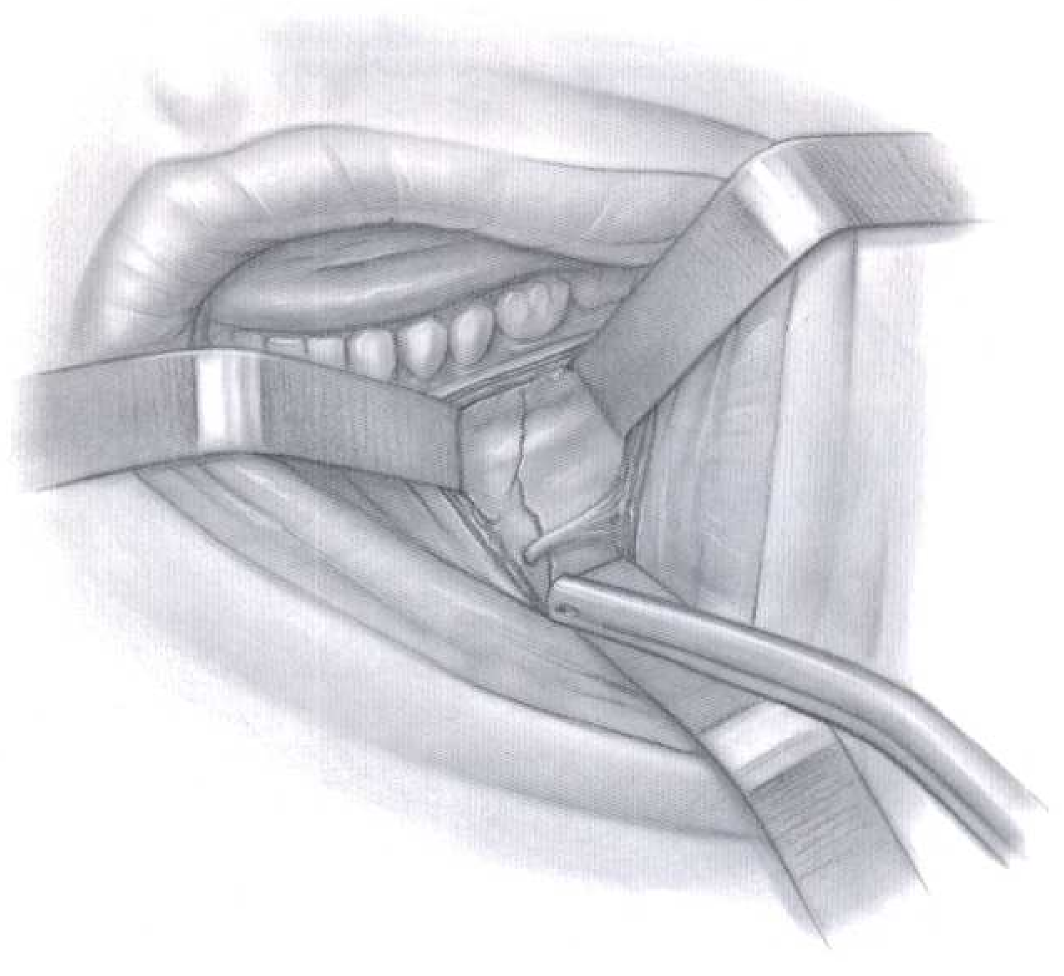


FIG. 3-6

Following plate application, the wound is irrigated, and the closure is accomplished in two layers. A suture of the surgeon's choice is used. The first layer is usually a running horizontal mattress suture. Following this, the closure of the second layer is performed, closing the everted edges of the mucosa in a simple continuous fashion. A compressive dressing aids in minimizing dead space, or a 19 gauge butterfly drain may be brought out through the skin under the mandible and placed into a vacuum tube for suction.

Mandibular Angle

The incision for approaching the angle is identical to that of a sagittal split ramus osteotomy.

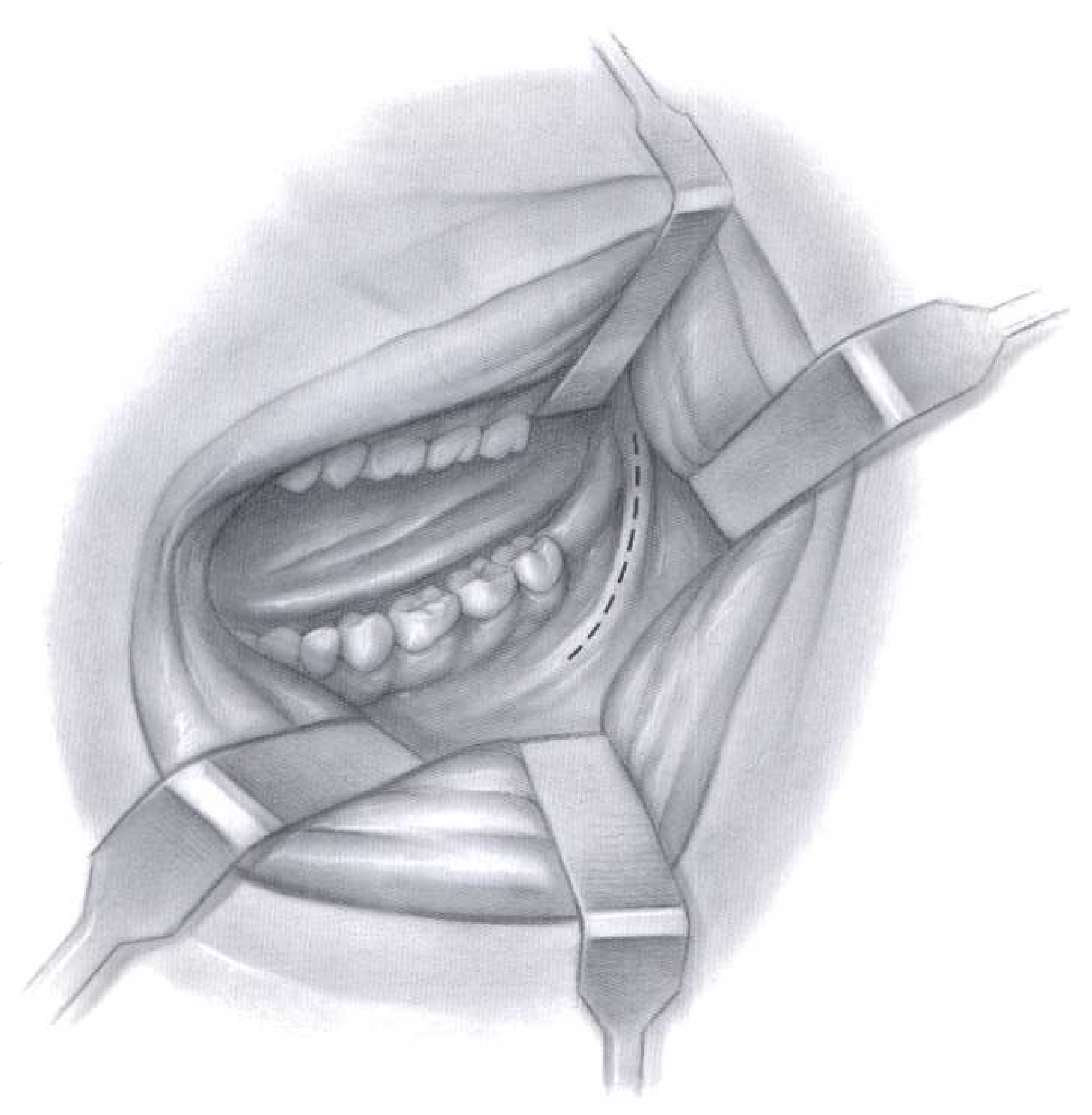


FIG. 3-7

The incision is begun on the anterior ramus at the level of the maxillary occlusal plane. It is then carried down just along the lateral portion of the anterior ramus and, following the oblique line, continues forward approximately 5 mm from the attachment of the mucosa and gingiva to extend anteriorly to the level of approximately the first molar.

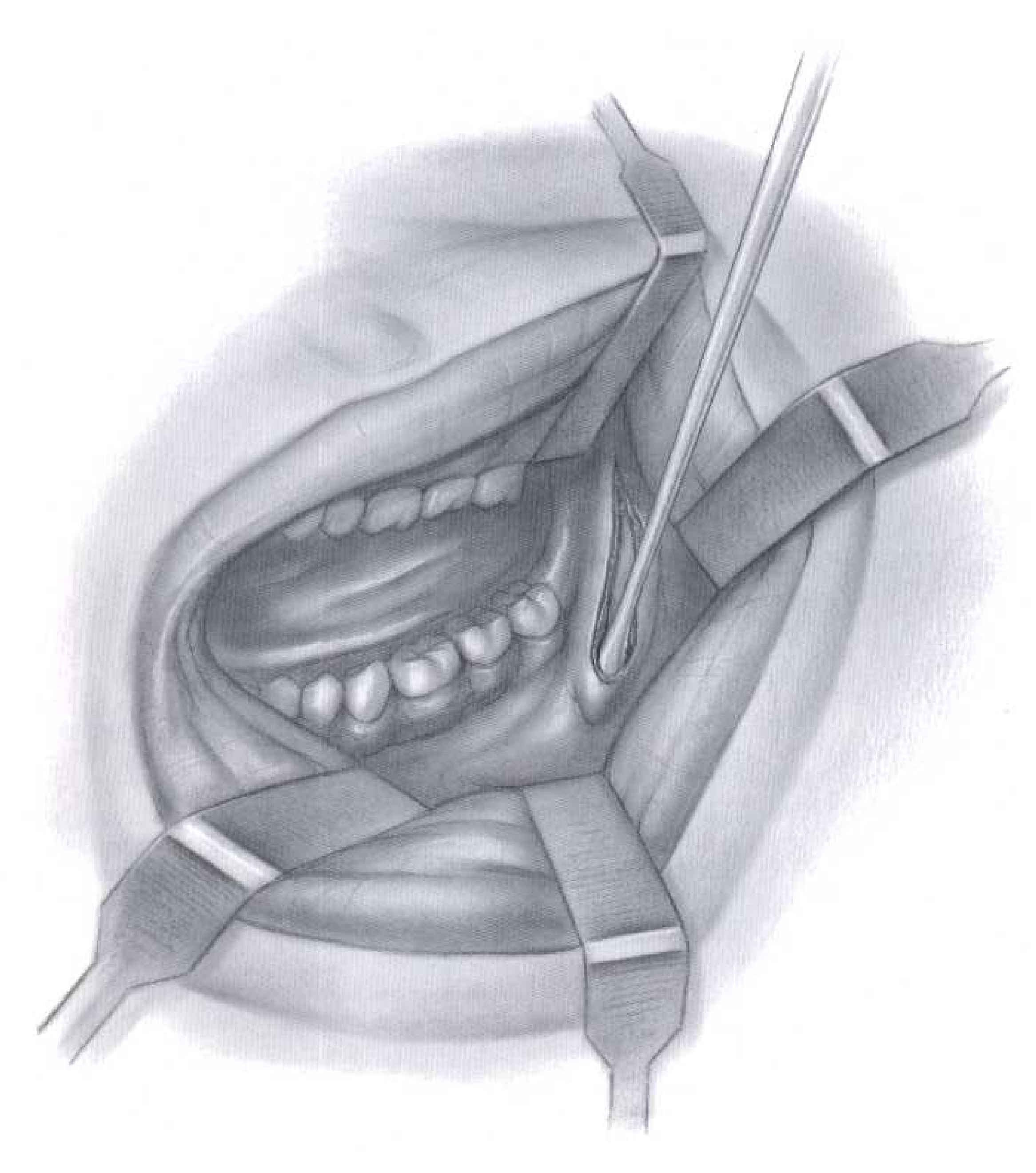


FIG. 3-8

After subperiosteal dissection and exposure of the fracture site, the tissue of the medial portion of the incision may be retracted to the contralateral side with either an elevator or a traction suture.

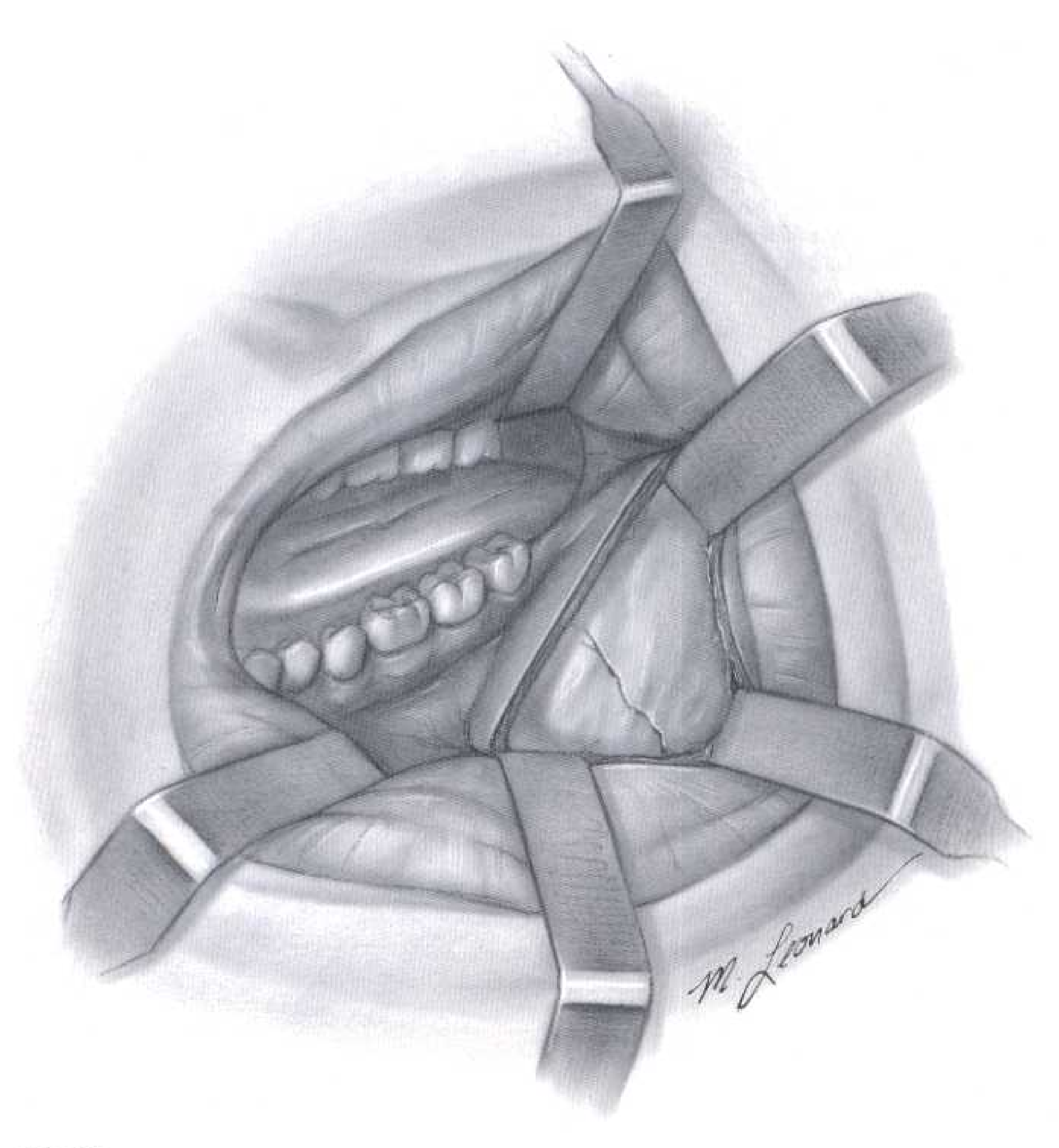


FIG. 3-9

If the incision is made too far laterally, then excessive tissue results on the medial portion of the incision, and this makes exposure of the oblique line in the retromolar trigone area much more difficult. If the incision is extended too far superiorly, then the buccal fat pad may be entered, which will protrude into the wound.

Following plate application, the wound is irrigated, and the closure is accomplished in two layers. A suture of the surgeon's choice is used. The first layer is usually a running horizontal mattress suture. Following this, the closure of the second layer is performed, closing the everted edges of the mucosa in a simple continuous fashion. A compressive dressing aids in minimizing dead space, or a suction drain may be brought out through the skin under the mandible.

Ramus/Subcondylar

The approach to the condylar region from an intraoral incision is similar to that for the angle. This approach is technically difficult and demands a great deal of experience from the surgeon. Since it is not commonly used and is difficult to illustrate, it has not been included in this book. As the surgeon becomes comfortable with exposure of the angle and coronoid process, condylar pathology may be addressed via this approach after reviewing indications for intraoral reduction and fixation.

EXTRAORAL

Symphysis and Parasymphysis

The skin is prepared with a preparation solution of the surgeon's choice. A vasoconstricting agent may be used to inject the proposed incision site if the surgeon so desires. An incision is made through the skin and subcutaneous tissue in a horseshoe-like fashion following the inferior border of the mandible.

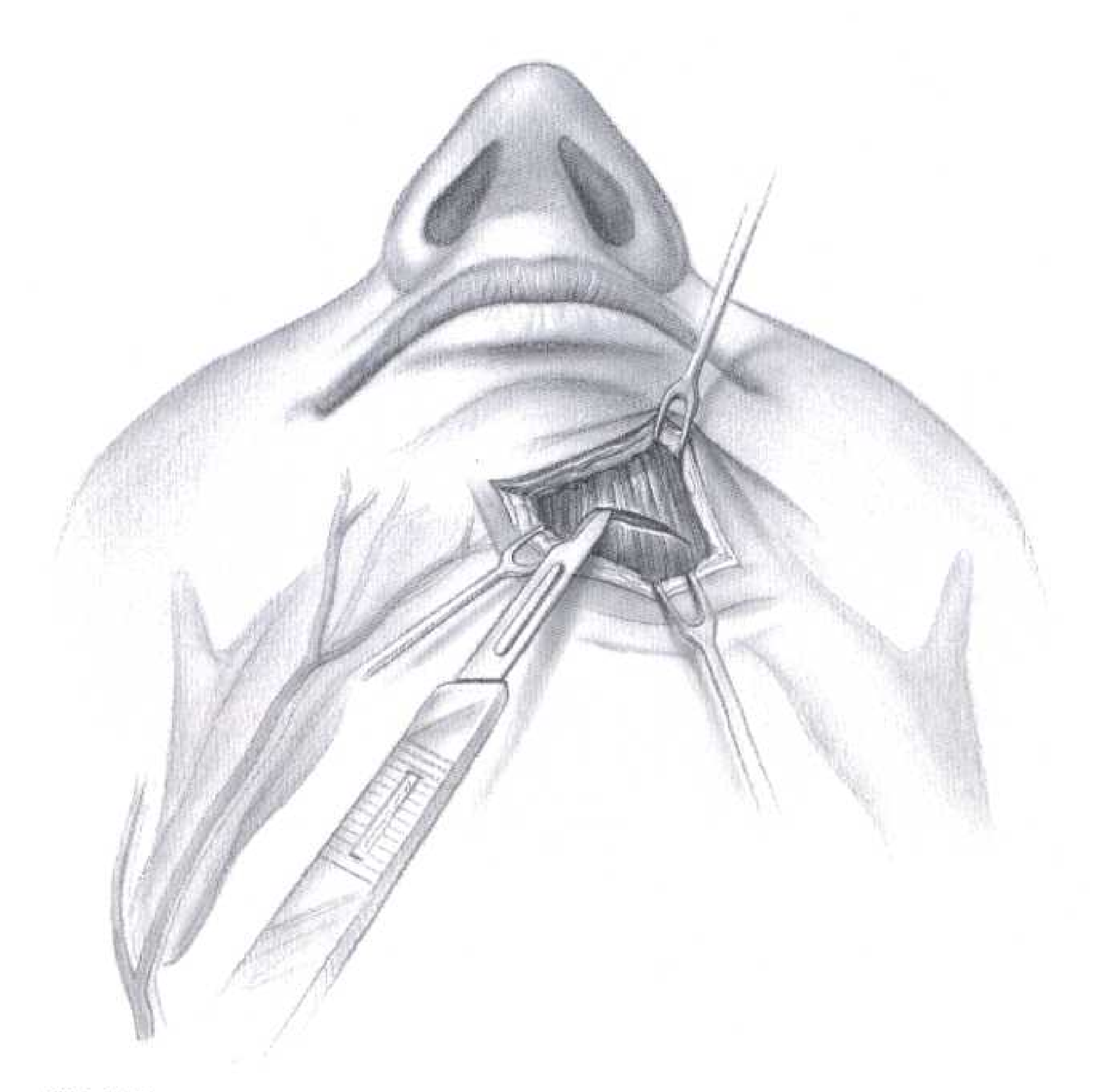


FIG. 3-10

After adequate hemostasis, the incision is continued down through the platysma to the inferior border of the mandible. At this point, an incision is made in the mandibular periosteum, and a periosteal elevator is used to dissect the periosteum from the buccal cortex of the mandible.

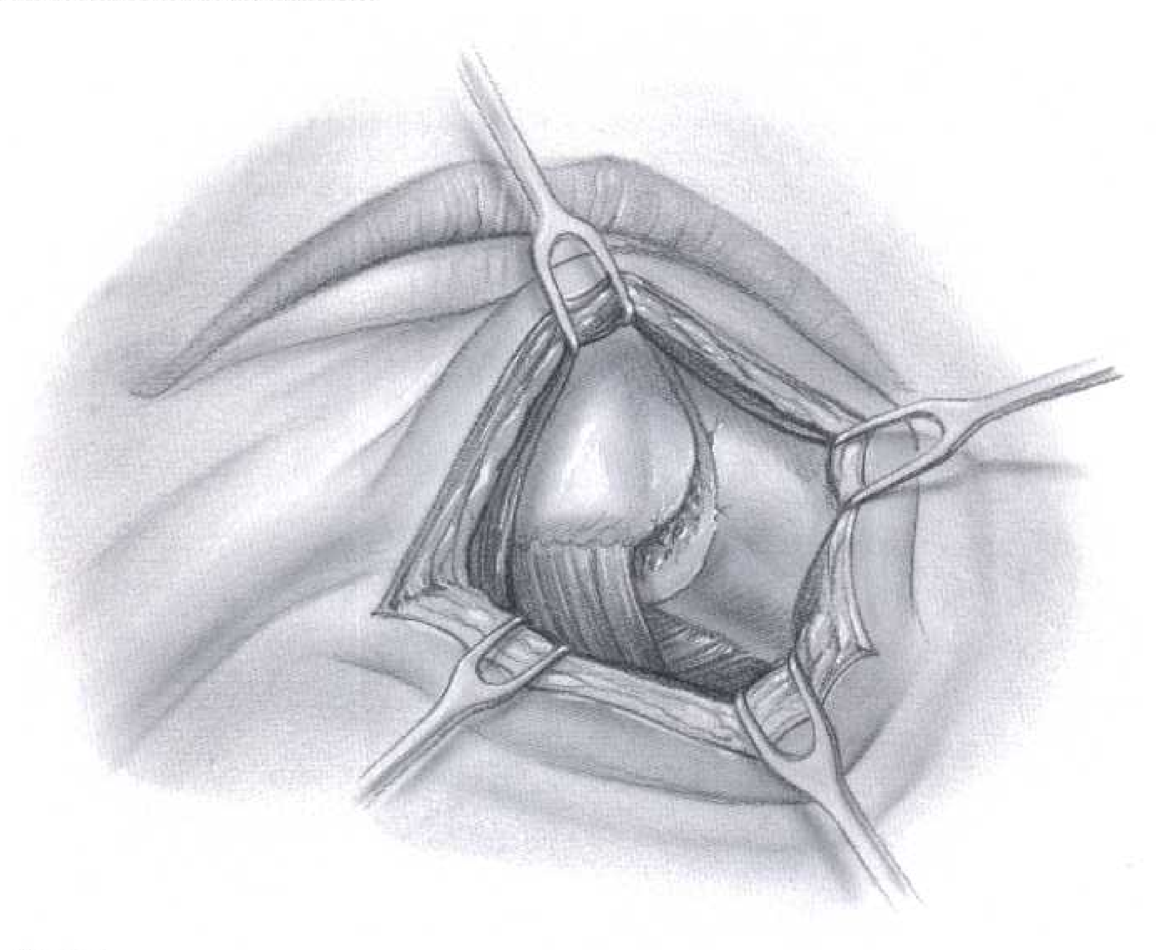


FIG. 3-11

After the application of plate fixation, the wound is irrigated and then closed in layers with a suture technique and material of the surgeon's preference. If significant dead space occurs, a drain should be used that may easily be removed at 24 hours.

Mandibular Body/Angle

The incision should be made in a natural skin crease. Since the incision will be carried only through the skin and subcutaneous tissue, this may be higher toward the inferior border of the mandible.

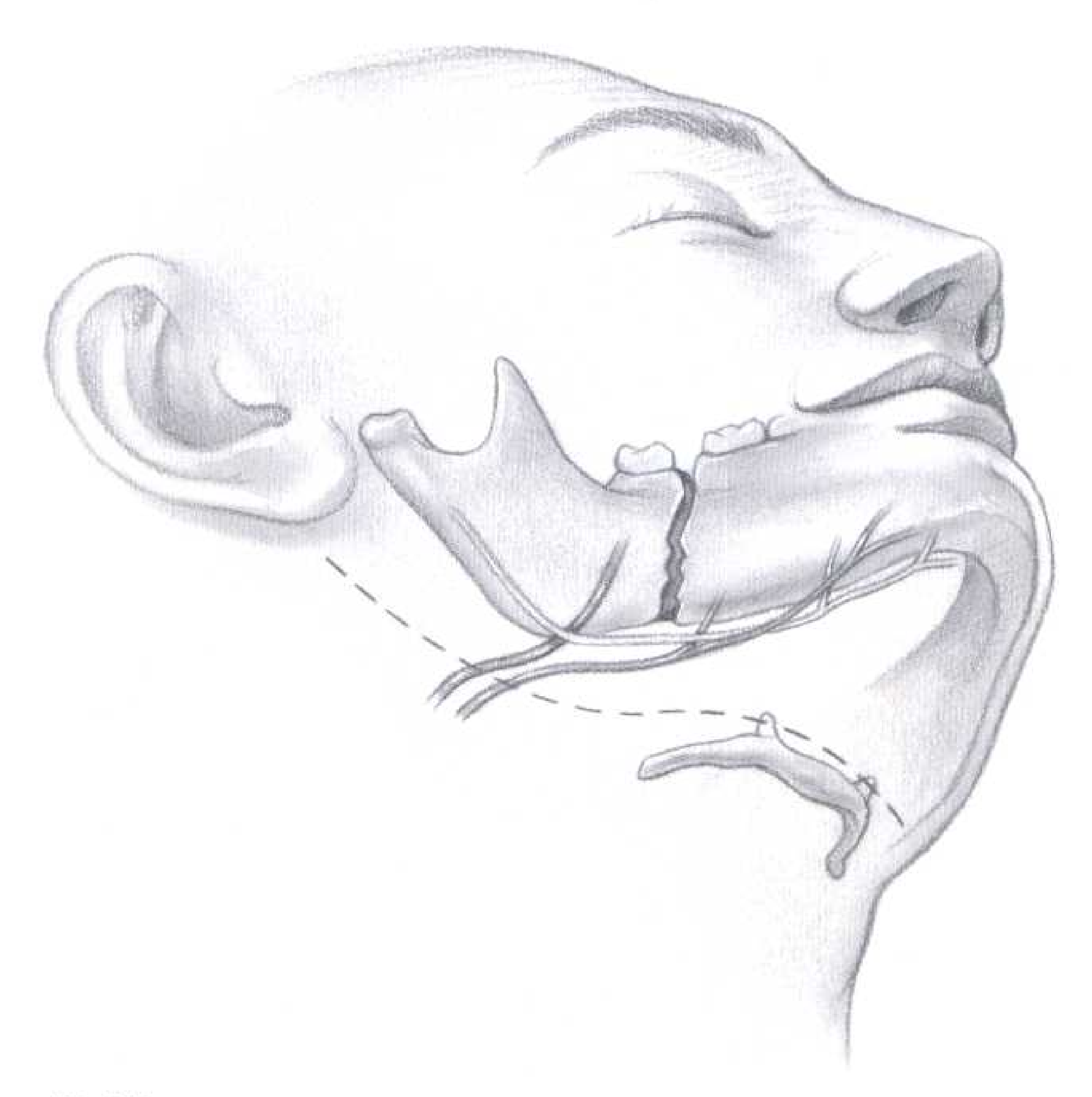


FIG. 3-12

After the incision is carried down through the skin and soft tissues, the dissection may then proceed inferiorly above the platysma to a level of approximately two fingerbreadths below the mandible. At this point, the platysma is incised, and the dissection is then turned deep to the platysma in the subplatysmal plane. The dissection can then proceed superiorly toward the inferior border of the mandible. The marginal mandibular branch of the facial nerve courses through the operative site, and this nerve may be identified immediately beneath the platysma as the surgeon dissects superiorly. As an alternative, the dissection may be carried deeper through the deeper cervical fascia to approximately the level of the submandibular gland. The capsule of the gland is identified, and the dissection in this subfascial plane then allows the surgeon to approach the mandible deep to the marginal mandibular branch of the facial nerve. In this approach, the nerve is not identified. The surgeon must choose which of these approaches is best suited for a particular case.

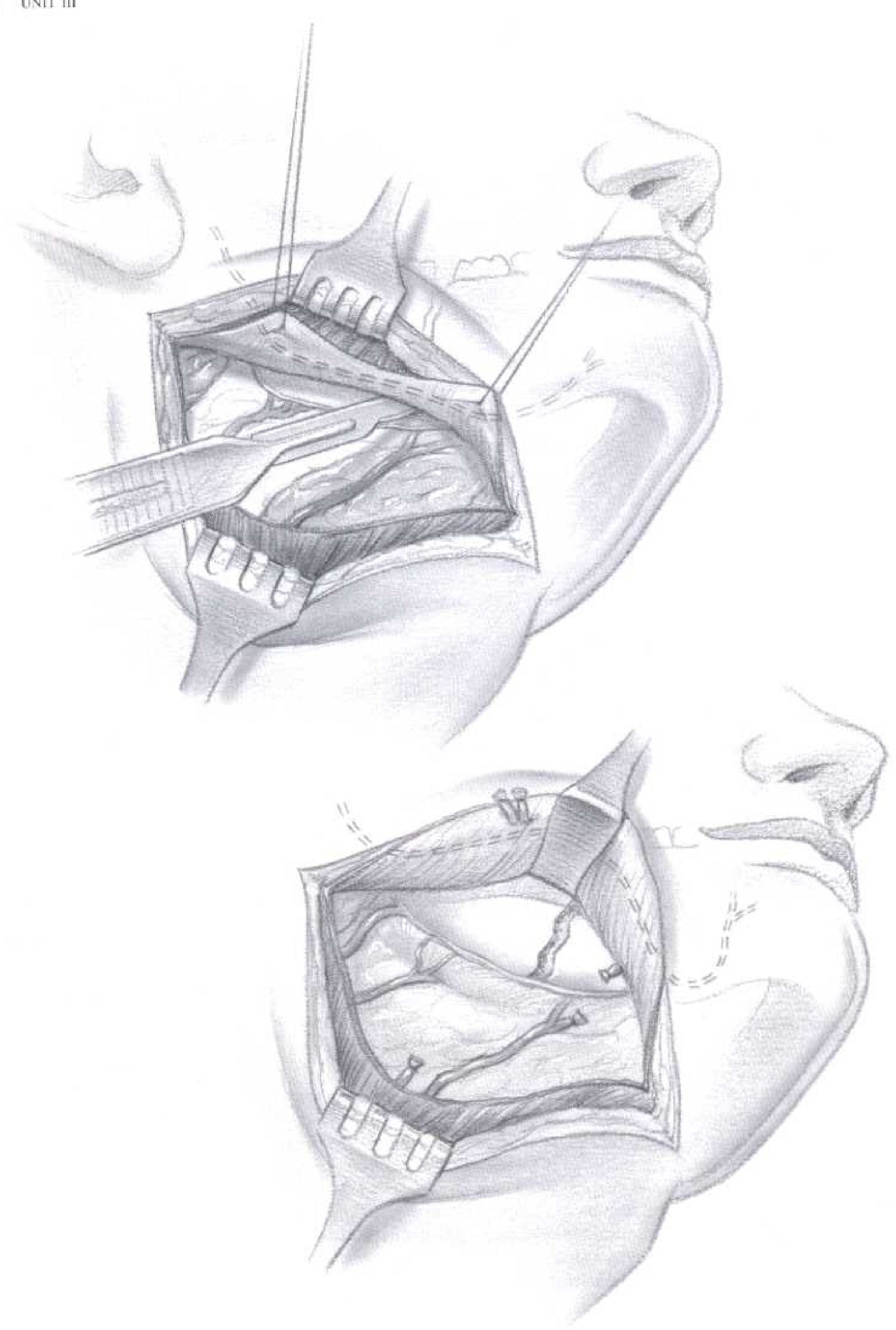


FIG. 3-13, 3-14

As the inferior border of the mandible is exposed, the periosteum is incised; attachments of the masseter muscle are also incised. A periosteal elevator is used to elevate the periosteum superiorly, and the fracture site is exposed.

After the fixation plate has been applied, the wound is closed in layers with a technique and suture of the surgeon's preference. A drain is normally used in this area because dead space is created during the dissection.

Ramus/Subcondylar

The extraoral approach to the ramus and condyle is similar to the approach to the angle. The incision and the exposure of the angle are covered in detail in the previous section. This exposure is useful as an approach to fractures of the ramus (horizontal, vertical, and oblique) and fractures of the subcondylar region in which the posterior aspect of the fracture traverses the ramus. Although it can be utilized for fractures of the condylar neck, significant traction is necessary for adequate exposure, and, this places the facial nerve under tension. The preauricular approach avoids this traction when used to expose high condylar fractures.

The technique for the initial exposure is described on pages 83-85. Following incision of the periosteum and masseter muscle insertion inferiorly, a periosteal elevator is used to perform a subperiosteal dissection of the angle and ramus of the mandible. The dissection is carried superiorly until sufficient exposure of the fracture site is achieved to allow application of the fixation device.

After the fixation plate is applied, the wound is closed in layers. A drain is normally used in this area because dead space is created during the dissection.

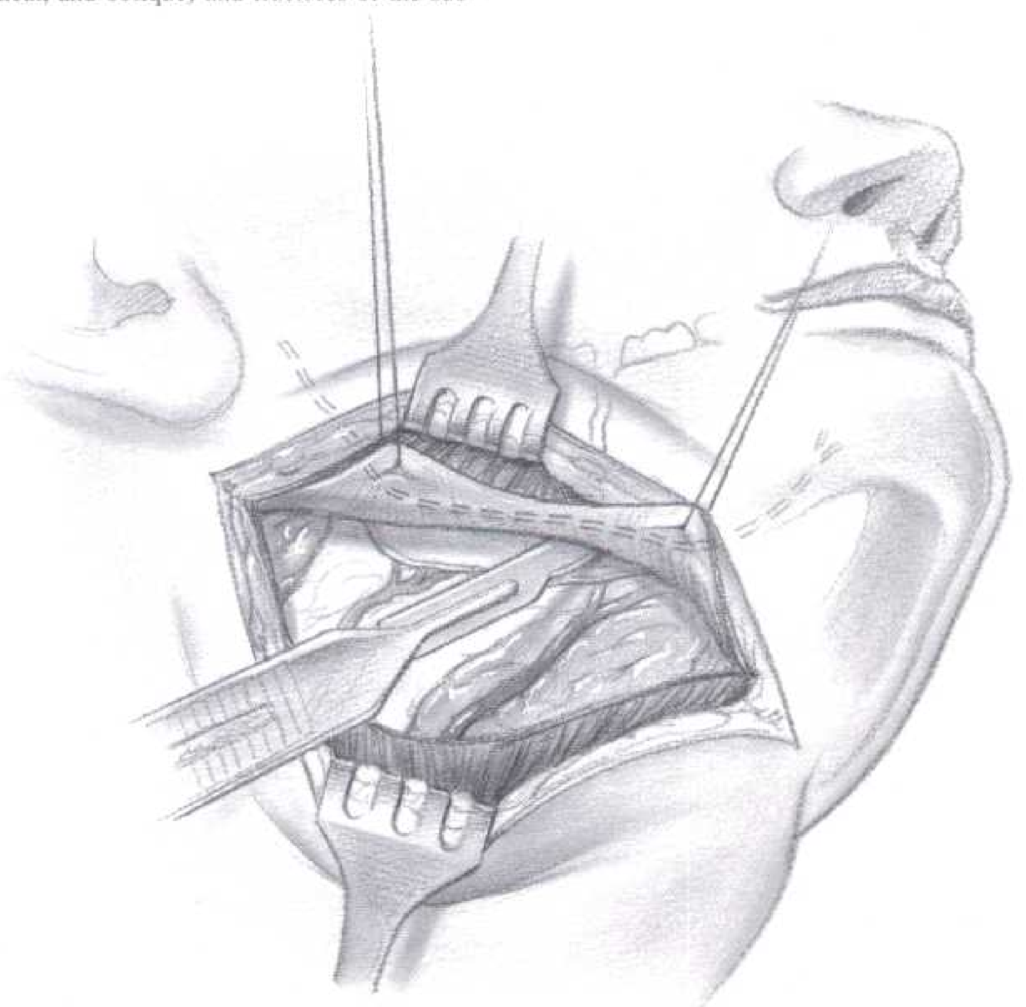


FIG. 3-15

Preauricular Approach

The preauricular approach allows wide exposure of the temporomandibular joint and condylar neck. The resultant scar is cosmetically acceptable and blends well with existing skin creases. The incision is identical to that used in a parotidectomy, eliminating that portion which extends inferior to the lobule. Since the frontal branch of the facial nerve courses in close proximity to the condylar region, forehead weakness or paralysis is possible secondary to nerve retraction or transection.

The incision is placed in a natural skin crease anterior to the auricle, starting at the level of the superior portion of the auricle and extending to the base of the lobule. It should follow the curvature of the tragus. Following the skin incision, the dissection is performed in the areolar tissue between the perichondrium of the tragus and the posterior capsule of the parotid gland. When the dissection reaches the level of the capsule of the temporomandibular joint, it proceeds anteriorly and inferiorly along the surface of the capsule. At the inferior insertion of the capsule and the condylar neck, the periosteum is incised and a subperiosteal dissection is carried out inferiorly toward the fracture site. Throughout the dissection, the overlying soft tissues are gently retracted keeping in mind the location of the facial nerve. Care must be taken also to avoid the auriculotemporal nerve and superficial temporal artery, although small branches of the artery will be encountered and may be cauterized with bipolar cautery. Once the fracture site is exposed, the fixation device may be applied following reduction. If necessary, the facial nerve may be identified and protected as it enters the parotid gland.

The wound is closed in layers in a cosmetically acceptable manner. A pressure dressing may be applied to reduce the possibility of postoperative hematoma formation.

CHAPTER 2

Mid and Upper Face and Skull

CORONAL APPROACH

Introduction

The coronal approach is a useful approach to obtain extensive exposure of the cranium and upper craniofacial skeleton, including the orbits and the nasal bones. The areas of exposure include the entire forehead, the anterior half of the cranium, and the entire zygoma, from the root of the zygoma and the temporal bone to the frontozygomatic suture and inferiorly along the inferior orbital rim to the infraorbital foramen. Medially, the exposure extends over the root of the nose and the nasofrontal suture onto the nasal bones and to the upper lateral cartilages, and with further extension of the dissection, to the nasal tip itself. The entire orbit may be skeletonized, including the superior and lateral orbital rims, the orbital floor, and the medial canthal ligaments and lacrimal sac. It is useful when access to these areas is required in cases of elective osteotomies or in cases of upper and midfacial fractures, including nasoethmoid complex fractures.

Postoperative infection is a rare complication. The most common complication is widening of the scar at the top of the head. Postoperative paresthesias posterior to the incision do occur, which are temporary in nature. Transient hair loss on each side of the incision and postoperative weakness of the temporal branch of the facial nerve that innervates the musculus frontalis are also seen less frequently. The decision as to whether the head should be shaved is solely left to the discretion of the surgeon. If dural exposure is not anticipated, then no shaving needs to be performed; however, shaving approximately a 2.0-cm wide strip at the incision site allows a firmer grip for the Rainey clips to provide hemostasis. The scalp is prepared with a preparation solution of the surgeon's choice, and the proposed incision site is marked and may be injected with a vasoconstricting agent. Right-angle retractors, such as the Langenbeck type, periosteal elevators (e.g., beaver tails and number 9s), or a fine-point dissecting hemostat, expedite coronal exposure.

Technique

With the patient in a supine position, the head is prepared and draped. The incision is made through the scalp, the subcutaneous tissues, and the galea into the loose areolar layer of the scalp between the galea and pericranium.

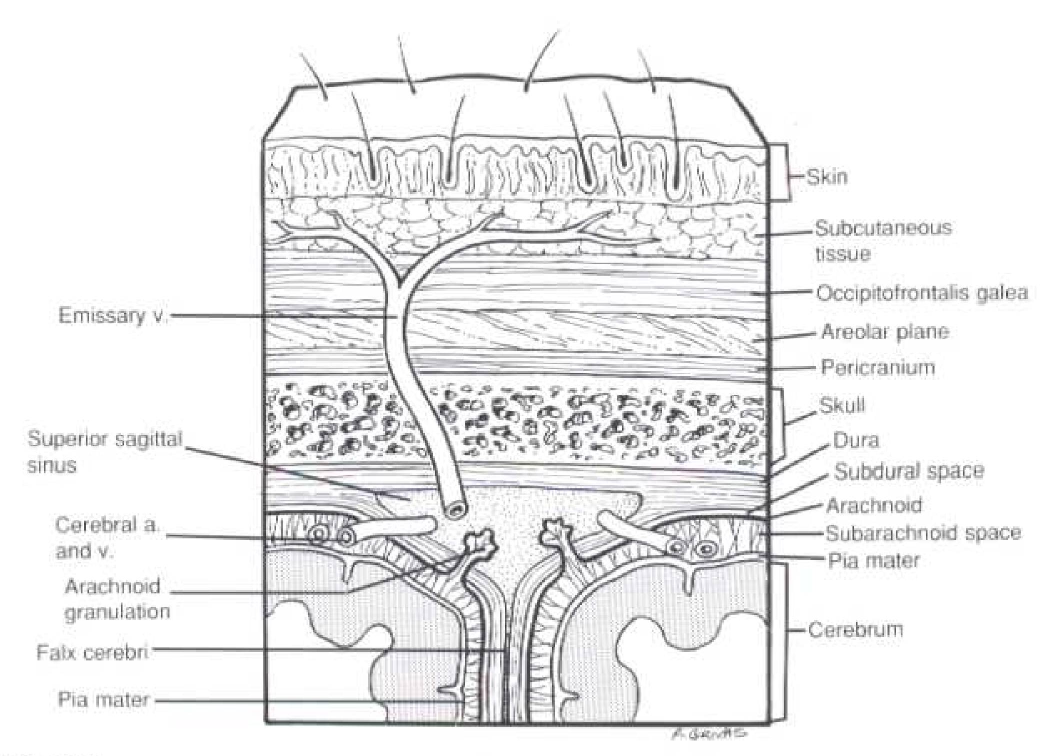
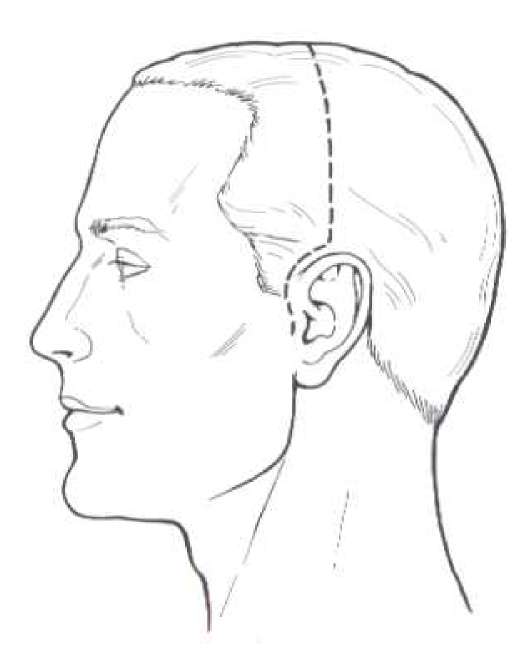


FIG. 3-16

The incision can be made initially in the midline, and hemostasis can be obtained with cautery, scalp clips, or running 0 silk locking suture.



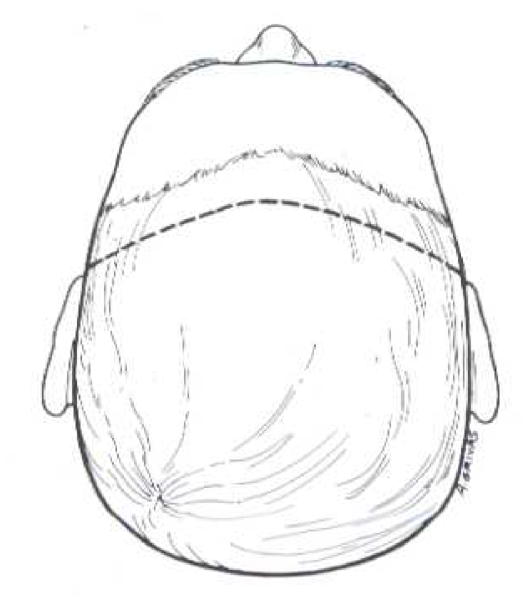
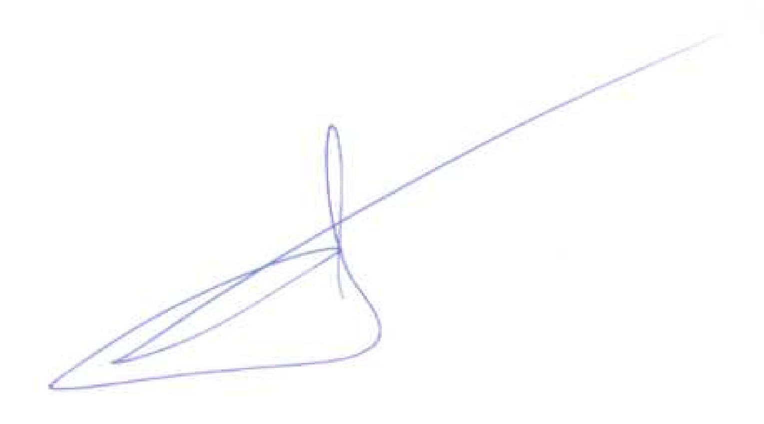


FIG. 3-17



After the initial midline portion of the incision is made, the remaining incision may be facilitated by having an assistant dissect laterally in the areolar layer between the galea and the pericranium using a hemostat. This allows the surgeon to quickly complete the incision in each direction, by cutting directly over the hemostat down through the galea, without concern for inadvertant penetration of the pericranium.

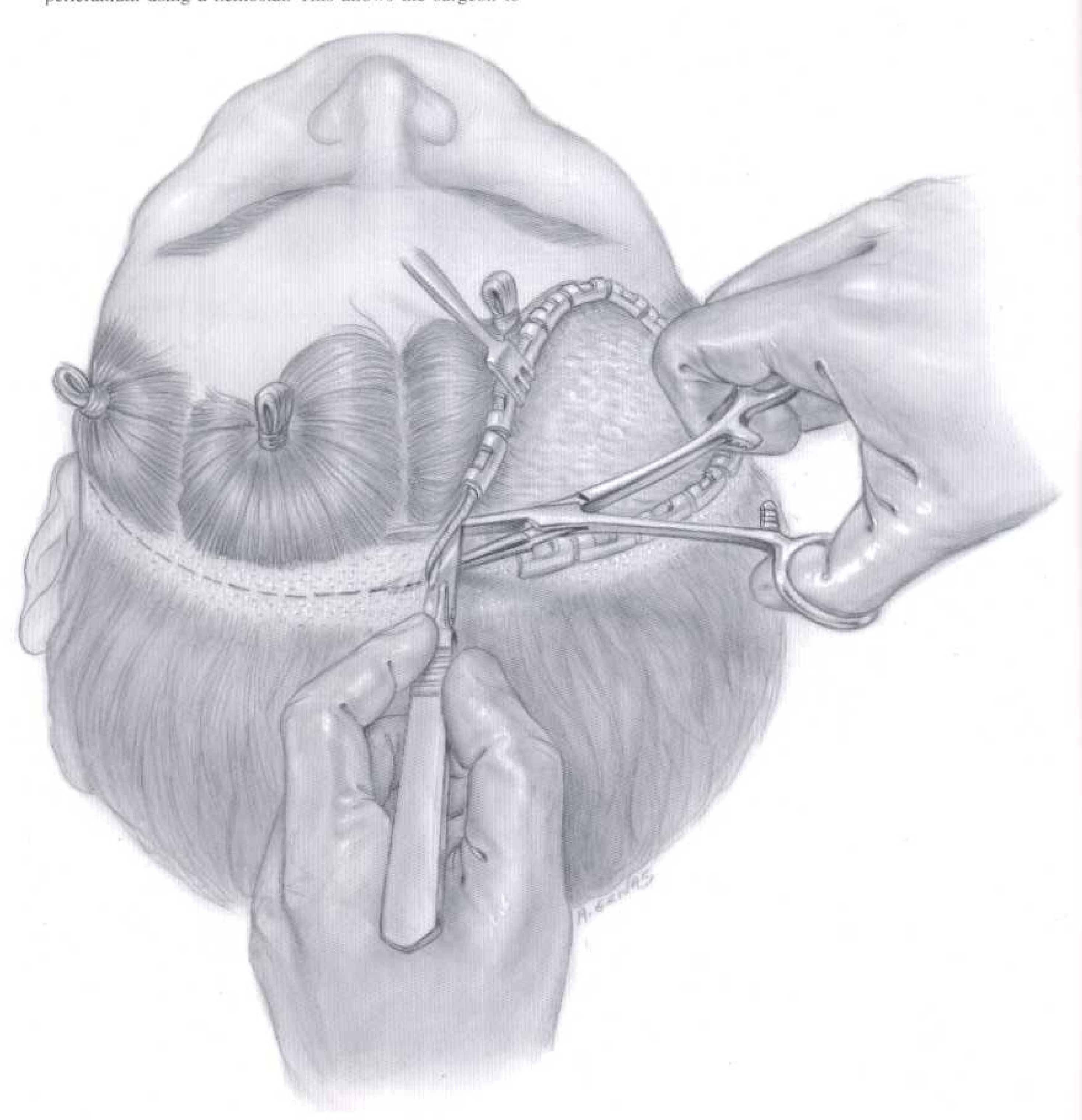


FIG. 3-18

Continued hemostasis is achieved until the incision is complete, usually from pretrageal area to pretragus. If exposure of only one zygoma is required, then the incision need not extend all the way into the contralateral pretrageal region.

The dissection is then carried anteriorly in the areolar subgaleal plane, dissecting toward the coronal suture and the supraorbital rims. The dissection here is relatively bloodless and may be facilitated by the use of cutting cautery. The dissection proceeds forward past the coronal suture between both temporal lines, and laterally, the dissection is carried in the areolar layer overlying the temporalis fascia.

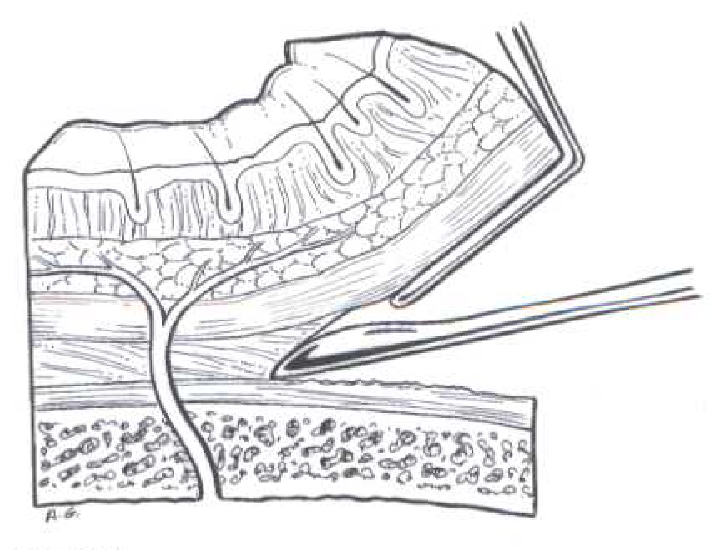


FIG. 3-19

However, care must be taken not to extend below the temporal line of fusion because injury to the temporal branch of the facial nerve may occur laterally as the nerve passes over the zygomatic arch. As the dissection proceeds anteriorly, the scalp can be everted.

At approximately 2.0 cm superior to the supraorbital rim, the pericranium is incised, and the dissection is continued directly over the bone. This subpericranial dissection continues to the supraorbital rims where the supraorbital neurovascular bundles are identified.

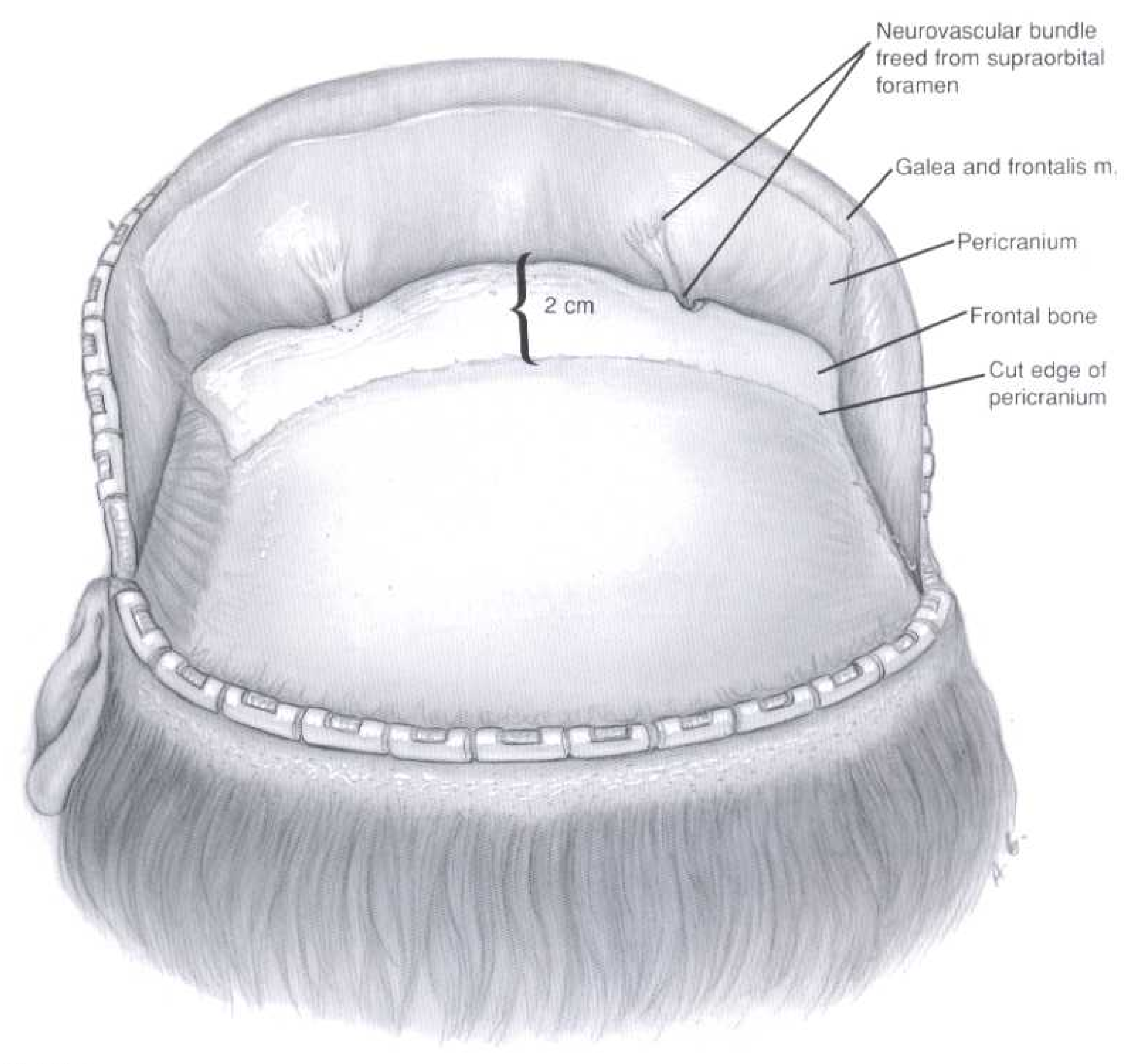


FIG. 3-20

If they are free in the notch, then they may be gently teased out of the notch and reflected forward into the scalp flap. However, if they are enclosed in a true foramen, a small osteotome is used to osteotomize and excise the bridge of bone along the inferior portion of the foramen (orbital side), thereby allowing decompression of the nerves and retraction of the nerves into the flap, thus preserving sensation to the forehead.

Lateral

Medial

Osteotomize inferior margin of supraorbital foramen

Alternative technique with curette

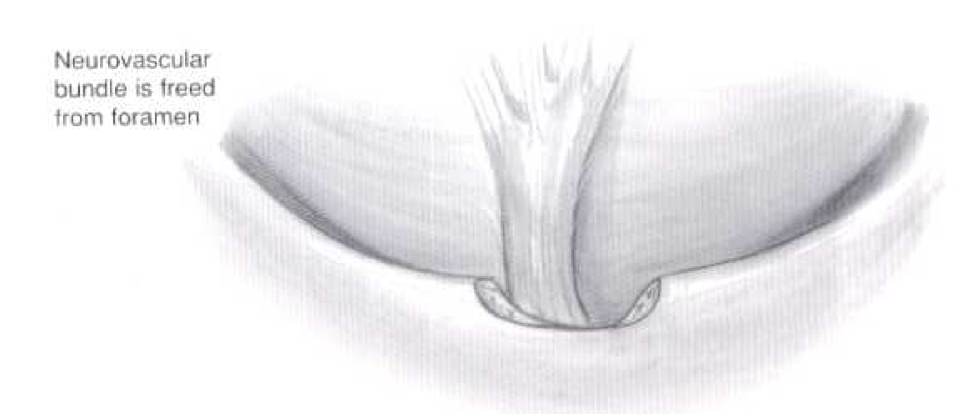


FIG. 3-21

The dissection may continue over the nasal bones at this point. However, if complete skeletonization of the upper facial bones is required, this is often easier to do after the lateral exposure has been accomplished.

The dissection is then turned laterally to the area overlying the temporal muscle. To avoid the temporal branch of the facial nerve, the temporal line of fusion of the superficial and deep layers of the deep temporal fascia is identified.

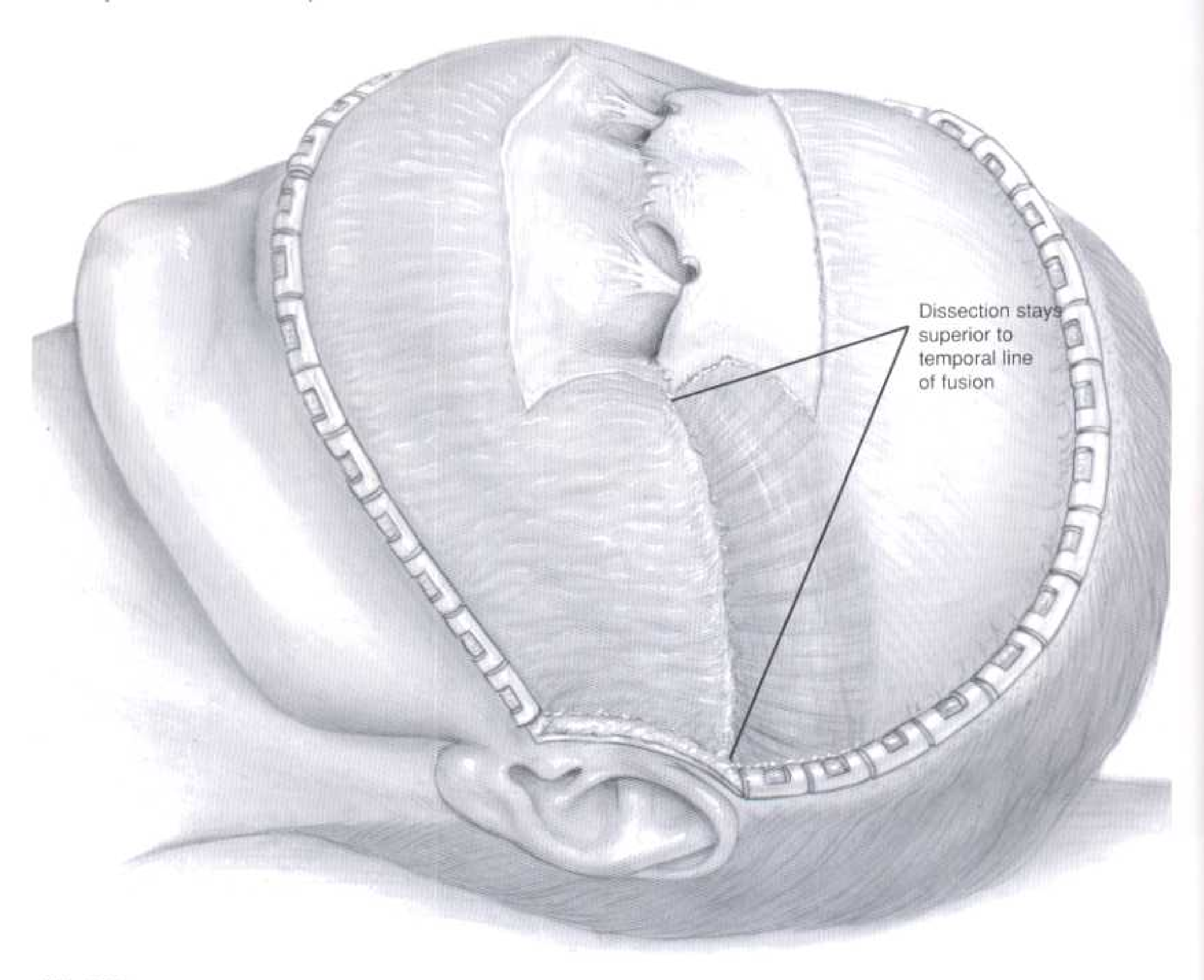


FIG. 3-22

If the dissection continues superficial to the fascia, then the frontal branch of the facial nerve is transected.

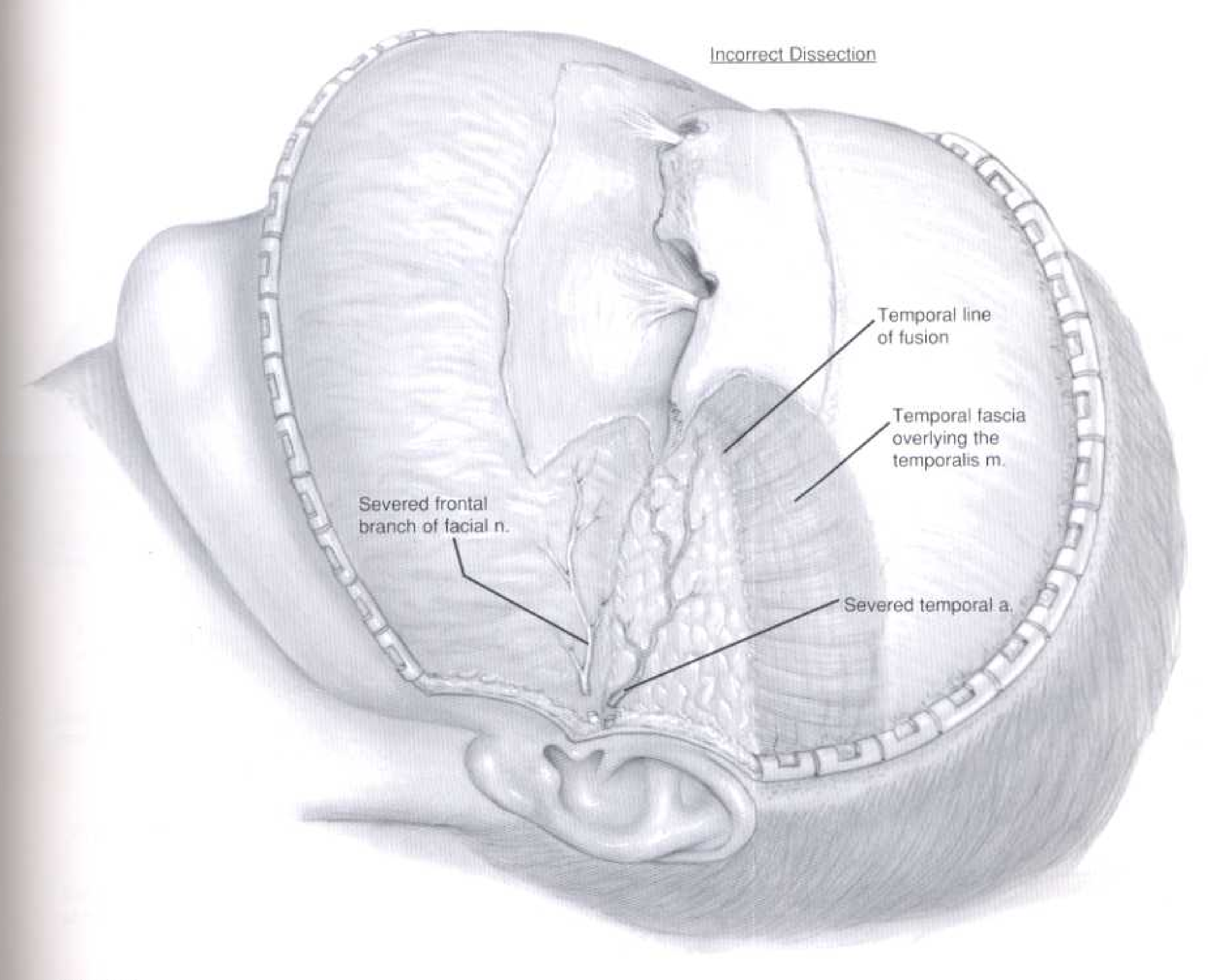


FIG. 3-23

Inferior to this line, a fat pad is seen. Incision of the superficial layer of the deep temporal fascia exposes the fat.

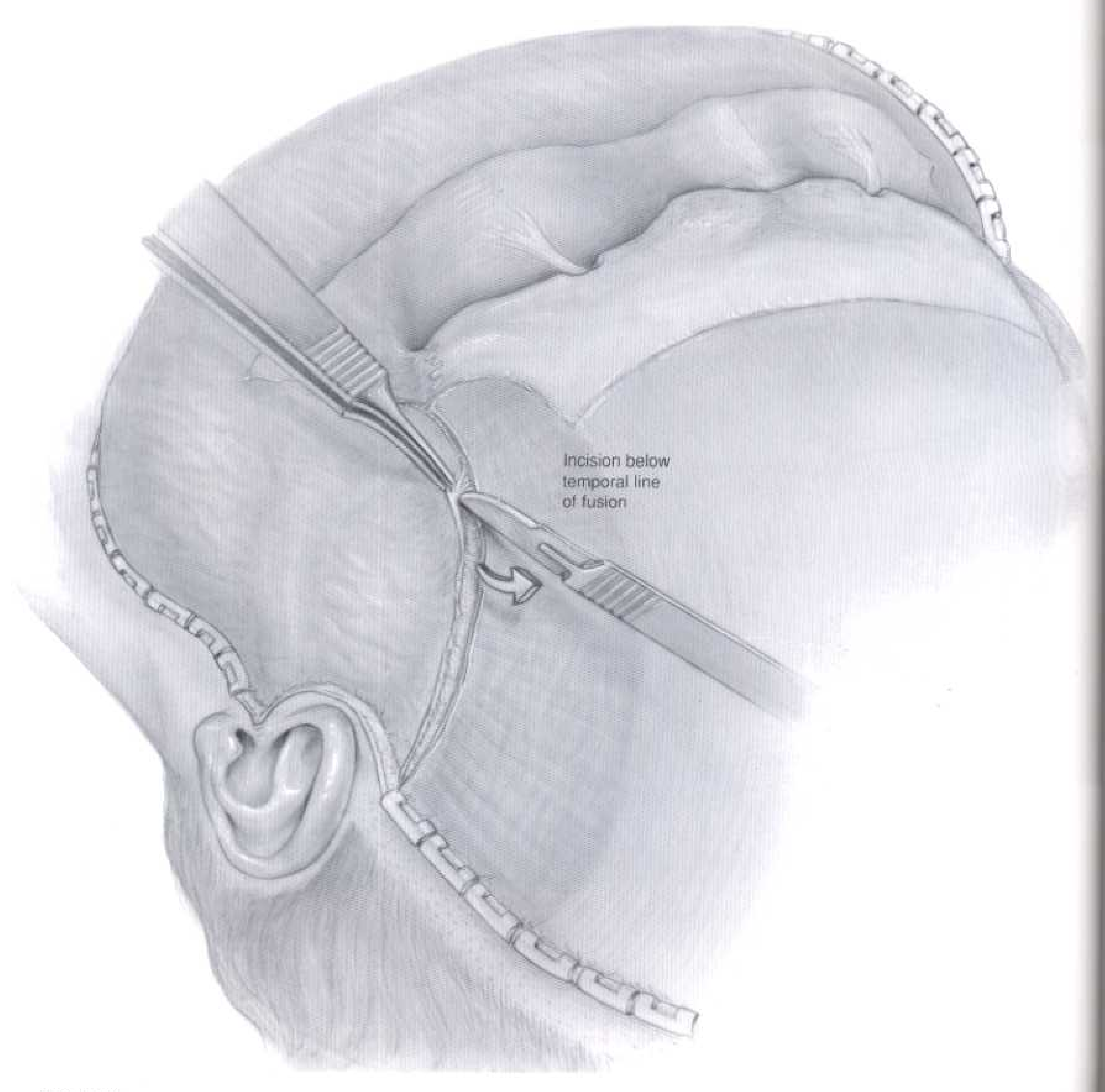
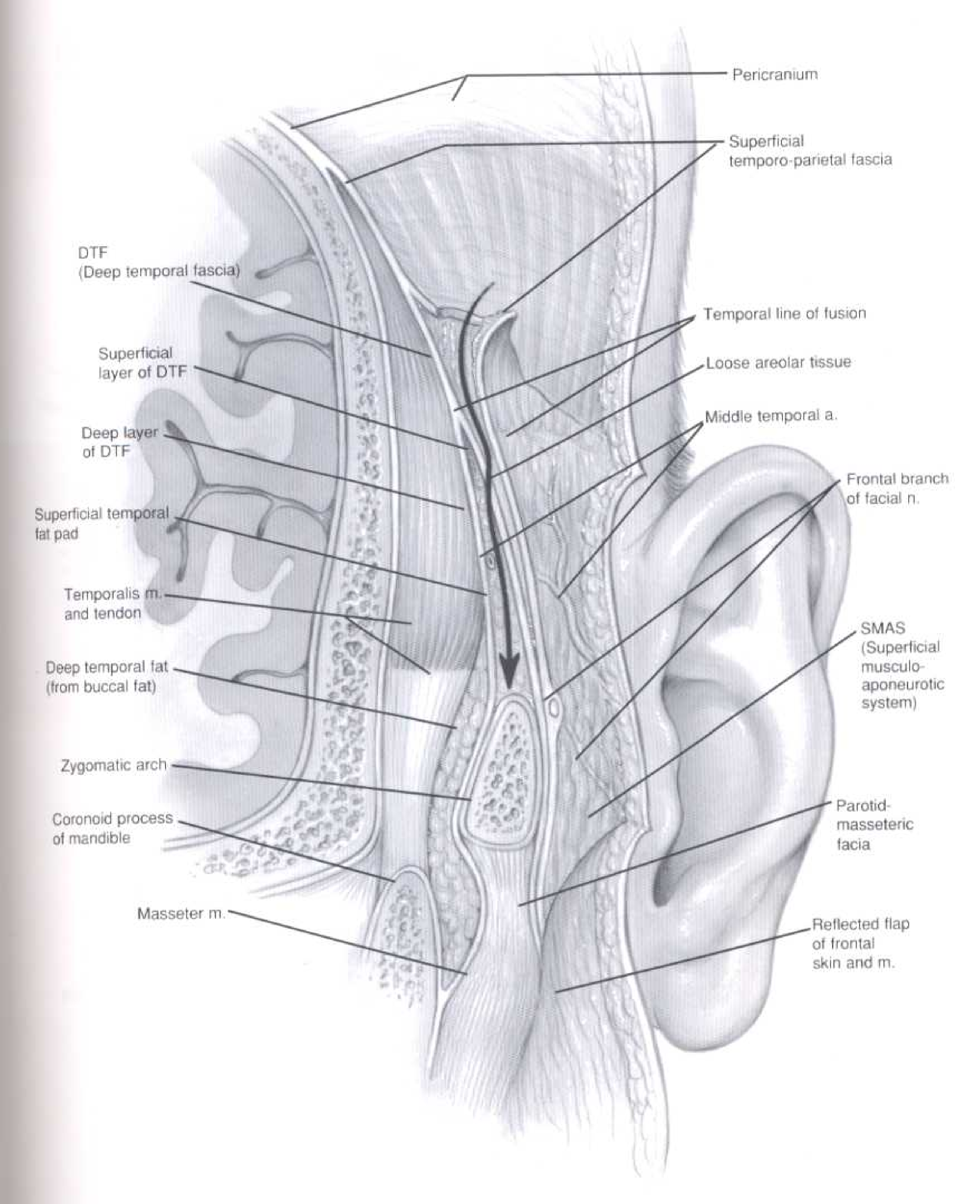


FIG. 3-24

After this is exposed, the dissection is then carried inferiorly in the fat pad to the zygomatic arch.



Pericranium
Superficial temporo-parietal fascia
DTF (Deep temporal fascia)
Temporal line of fusion
Superficial layer of DTF
Loose areolar tissue
Middle temporal a.
Deep layer of DTF
Frontal branch of facial n.
Superficial temporal fat pad
Temporalis m. and tendon
SMAS (Superficial musculo-aponeurotic system)
Deep temporal fat (from buccal fat)
Zygomatic arch
Parotid-masseteric facia
Coronoid process of mandible
Masseter m.
Reflected flap of frontal skin and m.

FIG. 3-25

Exposure is often easier if the surgeon angles the incision in the fascia backward and downward about 30°. Less temporal fascia is taken up in the flap, and much easier maneuverability of the flap itself is achieved.

The dissection continues through the fat pad to the zygomatic arch. The arch is approached initially at the root where the periosteum is incised along the superior portion of the arch.

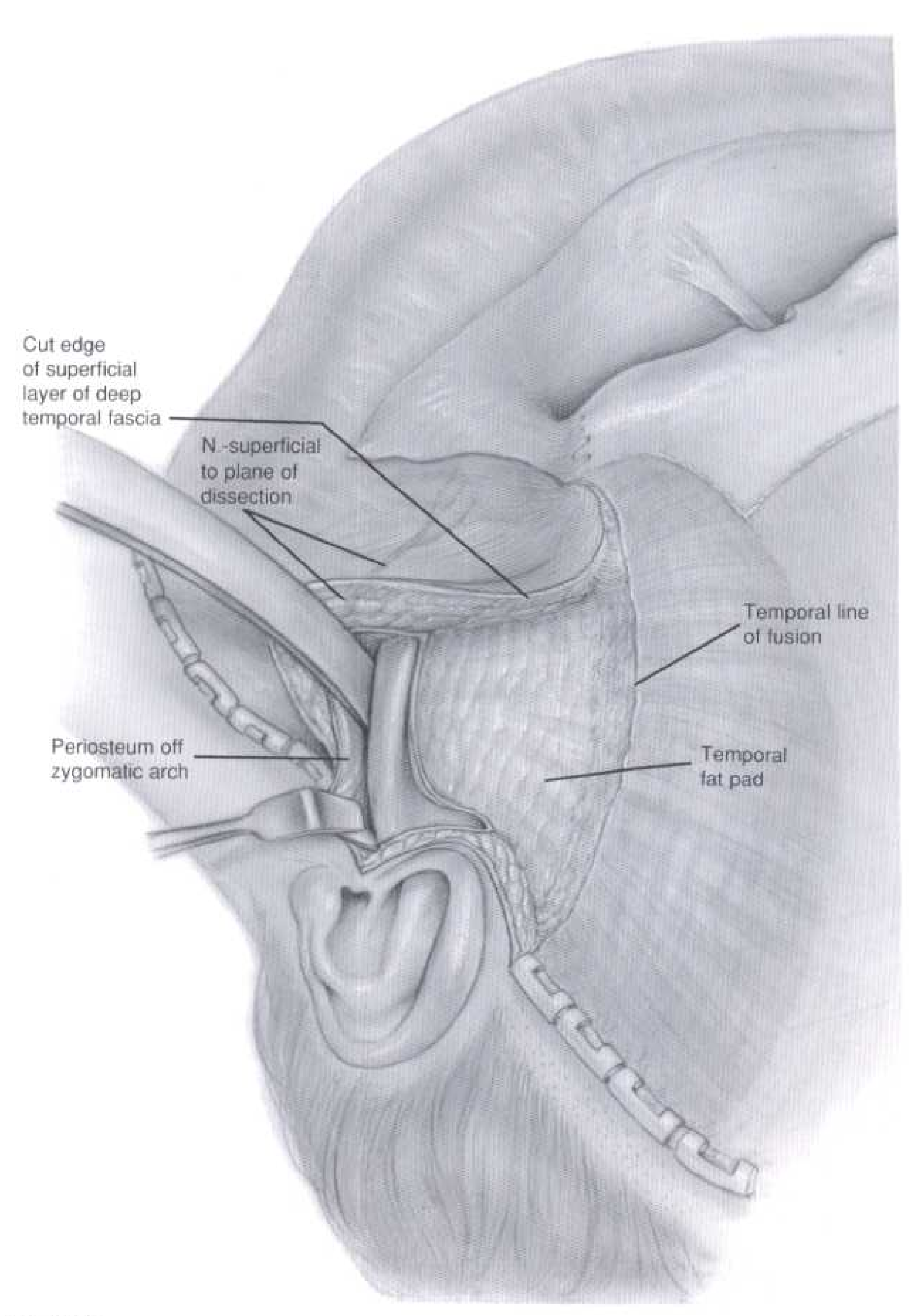


FIG. 3-26

A subperiosteal dissection is then performed, from superiorly and medially to inferiorly and laterally over the top of

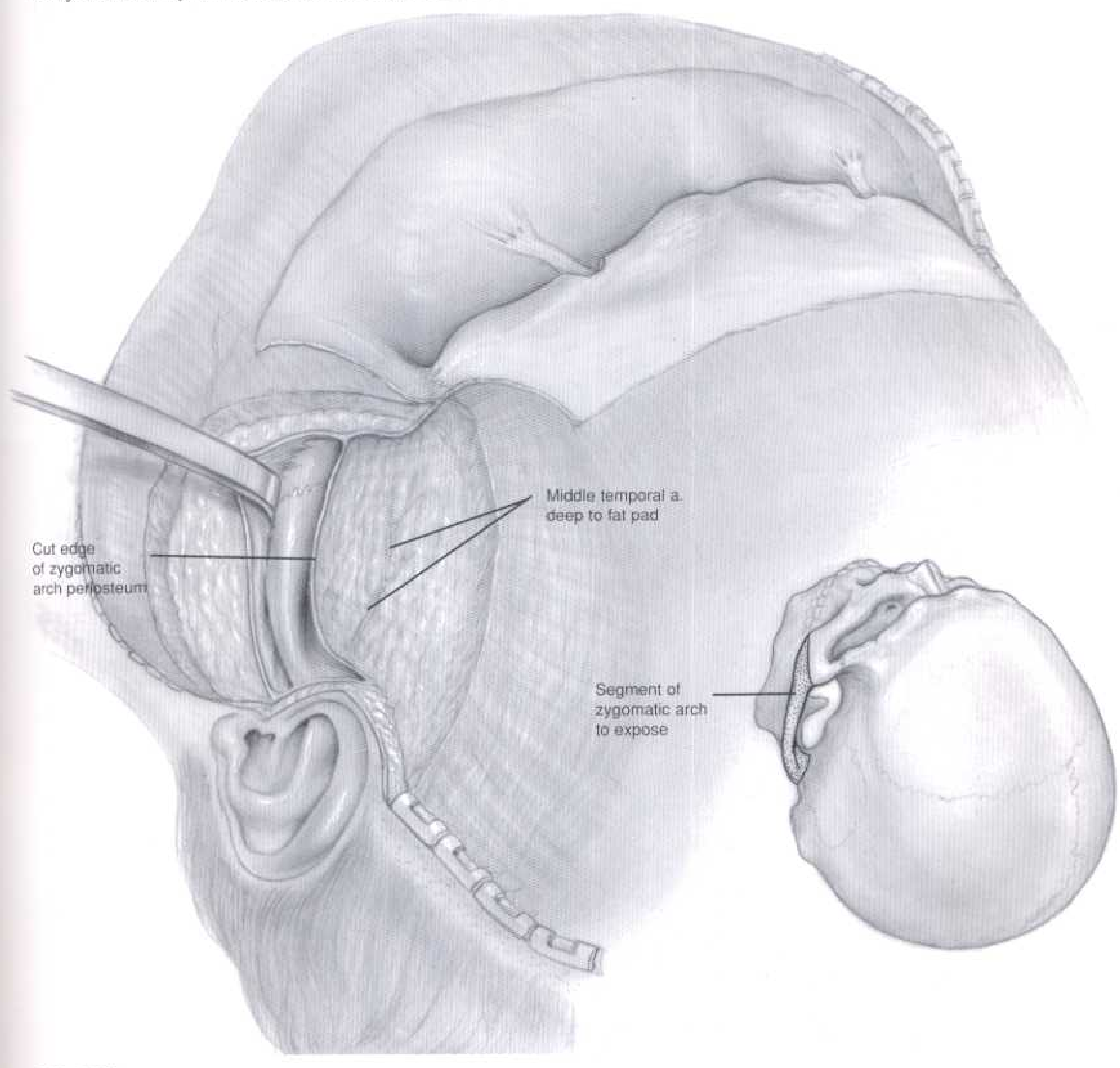


FIG. 3-27

The dissection proceeds anteriorly along the arch with this dissection technique. As the dissection proceeds, the temporal branch of the facial nerve is retracted laterally with the periosteum of the arch and the superficial layer of the deep temporal fascia.

At this point in the dissection, it is important to avoid the use of sharp instrumentation because penetration by a sharp instrument of the fascia and periosteum in this area could also lead to injury of the temporal branch of the facial nerve.

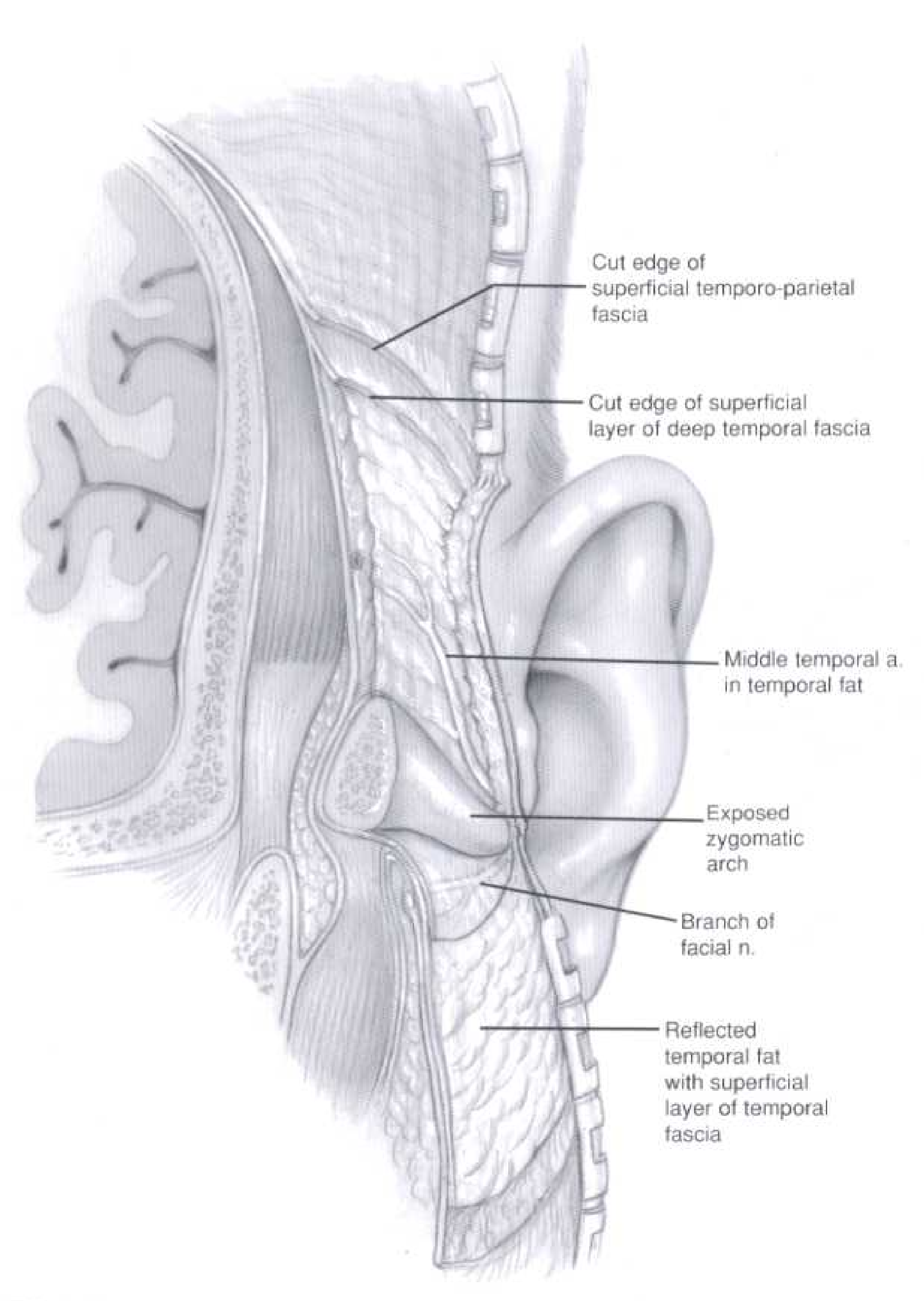


FIG. 3-28

As the dissection proceeds forward to the body of the zygoma, the fascia will be adherent to the periosteum at the lateral supraorbital rim from just below the level of the frontozygomatic suture to just above the juncture of the arch and body of the zygoma.

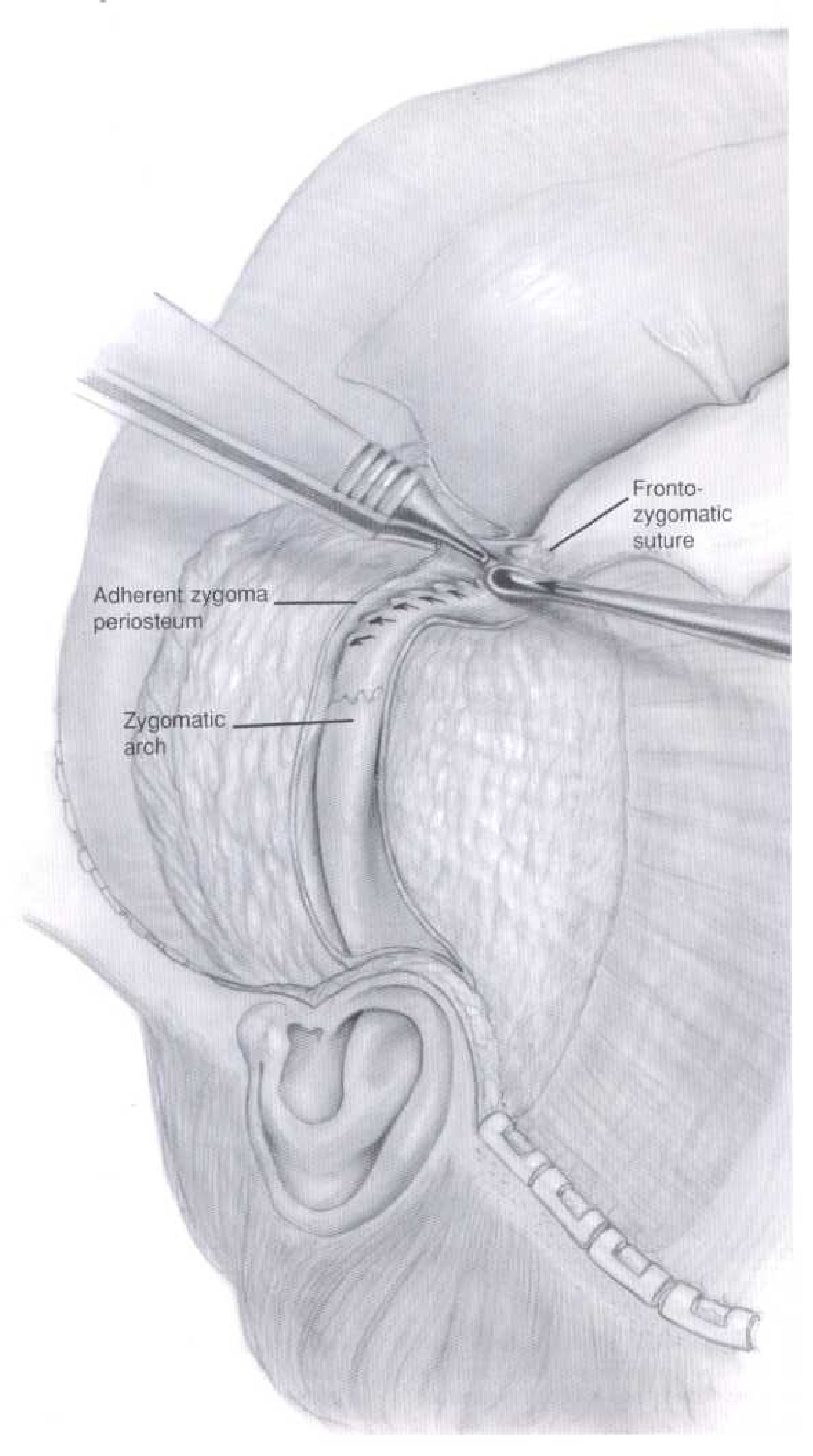


FIG. 3-29

After the surgeon has ascertained that the frontal branch of the facial nerve has been protected, this tissue may be sectioned along the lateral orbital rim by continuing posteriorly at the posterior edge of the zygoma as it enters the temporal fossa. After this has been achieved, the dissection then can proceed in a subperiosteal plane to the lateral orbital rim itself.

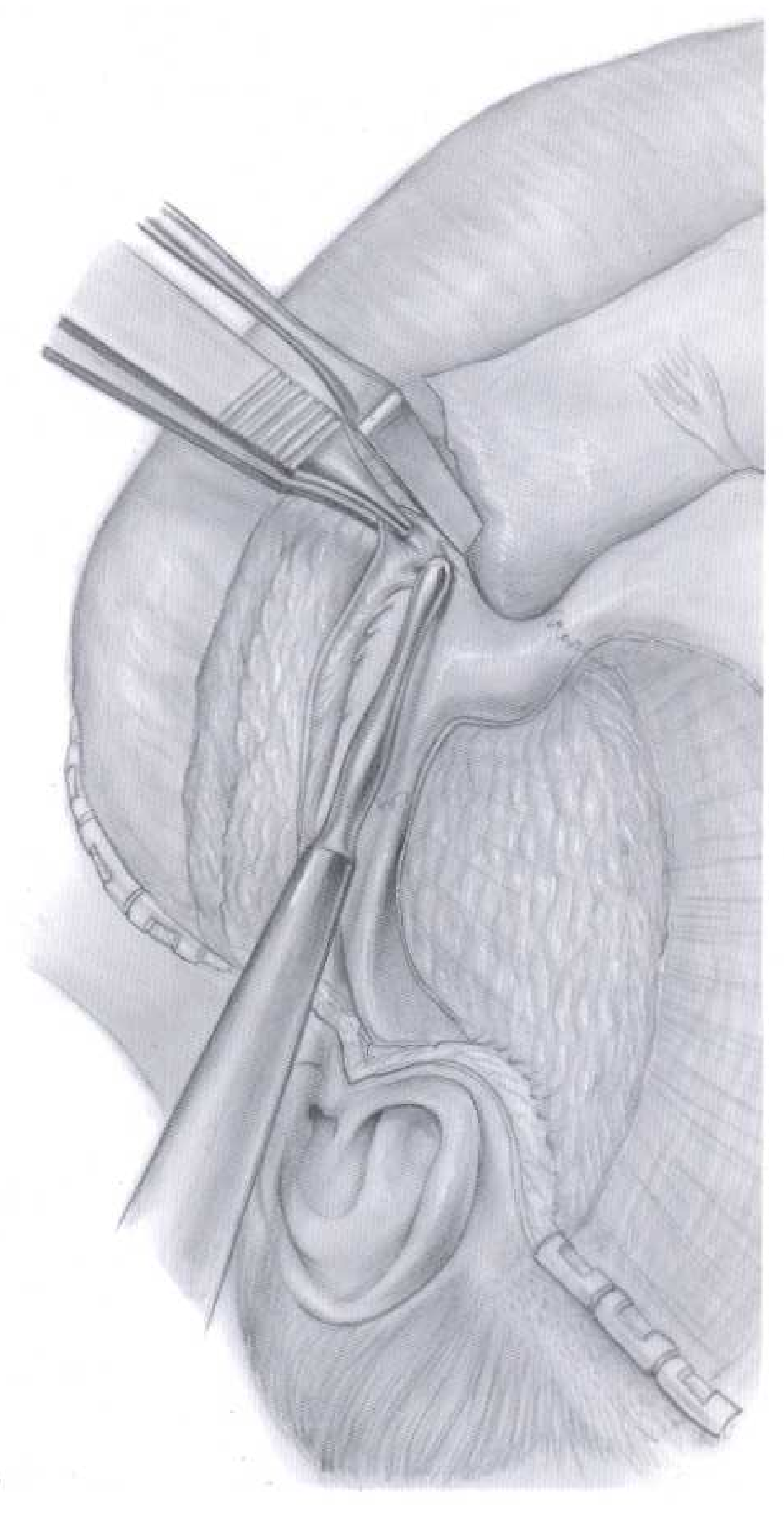


FIG. 3-30

If a total orbital exposure is necessary, then a curved periosteal elevator is used and placed in the orbit, and the periorbita and periosteum of the frontal bone and zygoma are elevated free from the underlying bone. This would include detaching the lateral canthal tendon, which may be reattached at the end of the procedure.

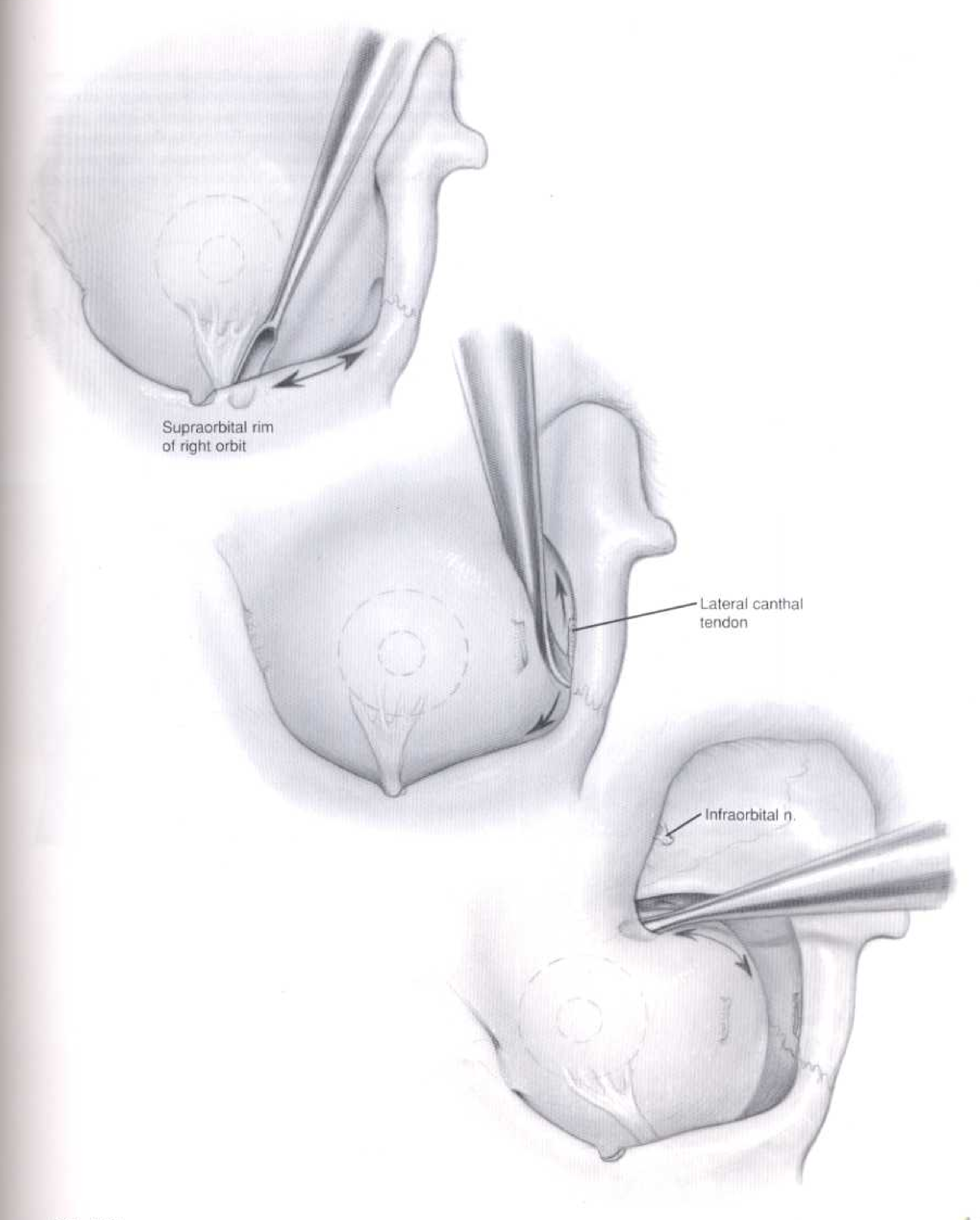

Supraorbital rim
of right orbit
Lateral canthal
tendon
Infraorbital n.

FIG. 3-31

The orbit then is skeletonized superiorly and laterally with the dissection continuing toward the floor of the orbit and the infraorbital rim. Dissection is continued subperiosteally and the infraorbital nerve and zygomatico-maxillary suture are exposed along with the anterior surface of the maxilla.

After this has been performed on both sides, it is then easier to complete the dissection of the root of the nose. Attention is turned to the medial portion of the face. The subperiosteal dissection proceeds over the glabella in the midline of the frontal bone to the nasofrontal suture. Some degree of resistance is noted here because there is adhesion of the periosteum at the nasofrontal suture. Following the release of this attached area, the dissection should proceed easily over the nasal bones themselves and, if necessary, it may be extended down along the upper lateral cartilages.

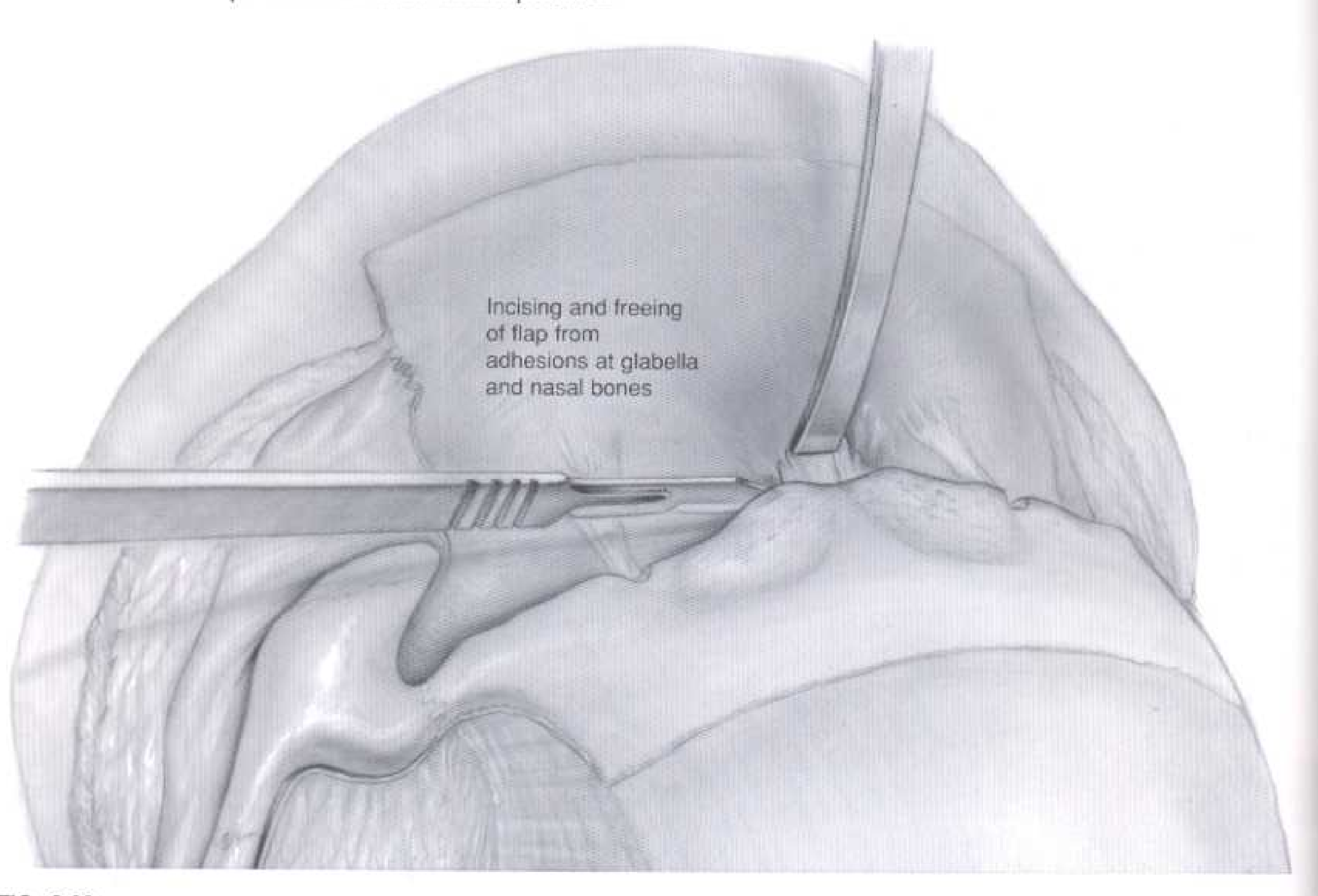


FIG. 3-32

If the medial orbital walls are involved in the injury or the osteotomy, then the exposure continues posteriorly into the orbit in a subperiosteal plane. The anterior and posterior limbs of the medial canthal ligaments and the lacrimal sac are identified. In this area, caution must be taken because injury to the anterior ethmoidal artery is possible. If the dissection must proceed into this area, the surgeon may use ligature clips to ligate and divide the artery, thereby reducing the chance for orbital hematoma formation.

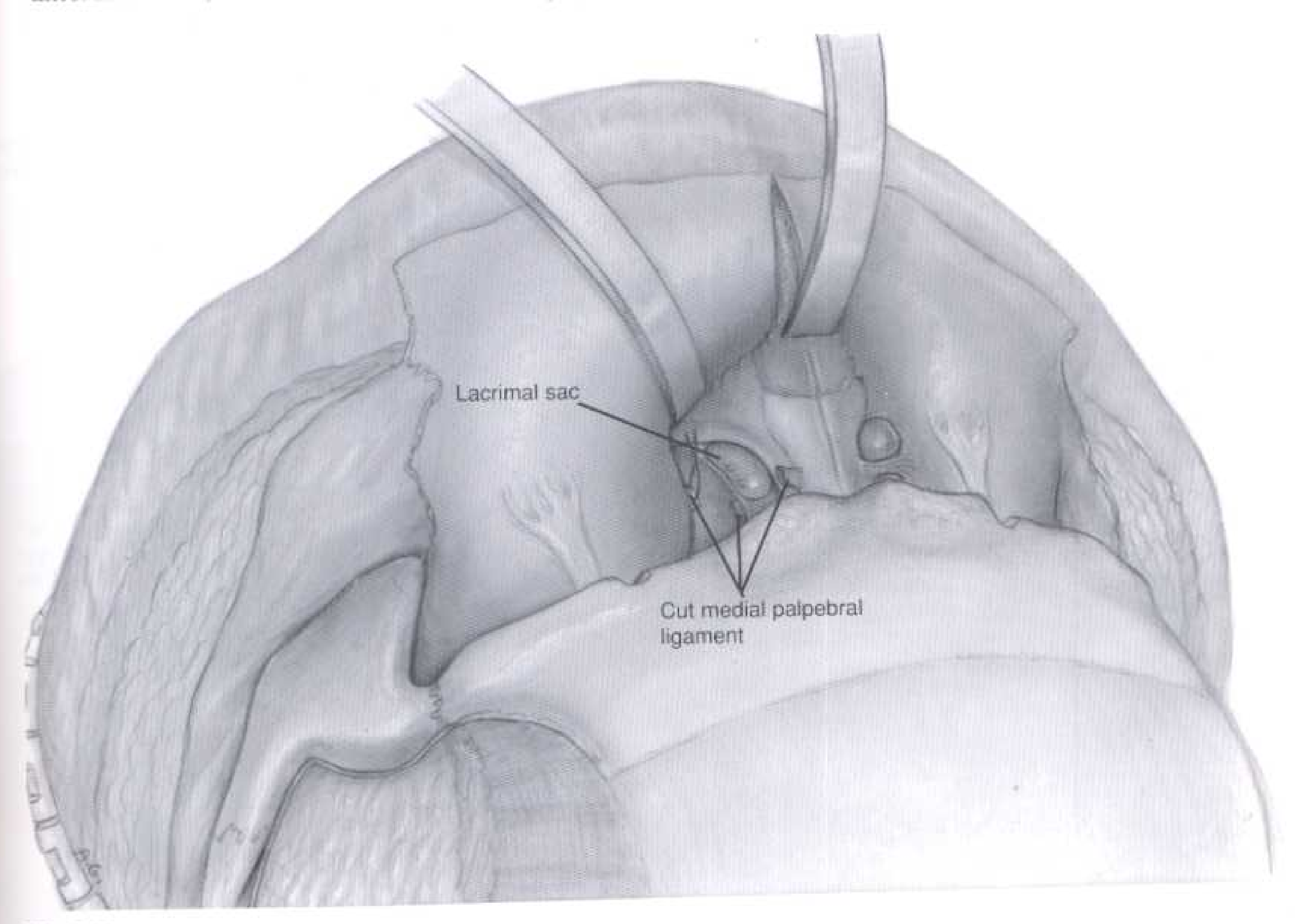


FIG. 3-33

Occasionally, retraction of the flap over the nasal bones may be difficult as a result of restriction by the periosteum. Scoring of the periosteum may be performed, thereby allowing for easier access to the nasal dorsum. Whether this periosteum requires closure at the end of the case is up to the discretion of the surgeon.

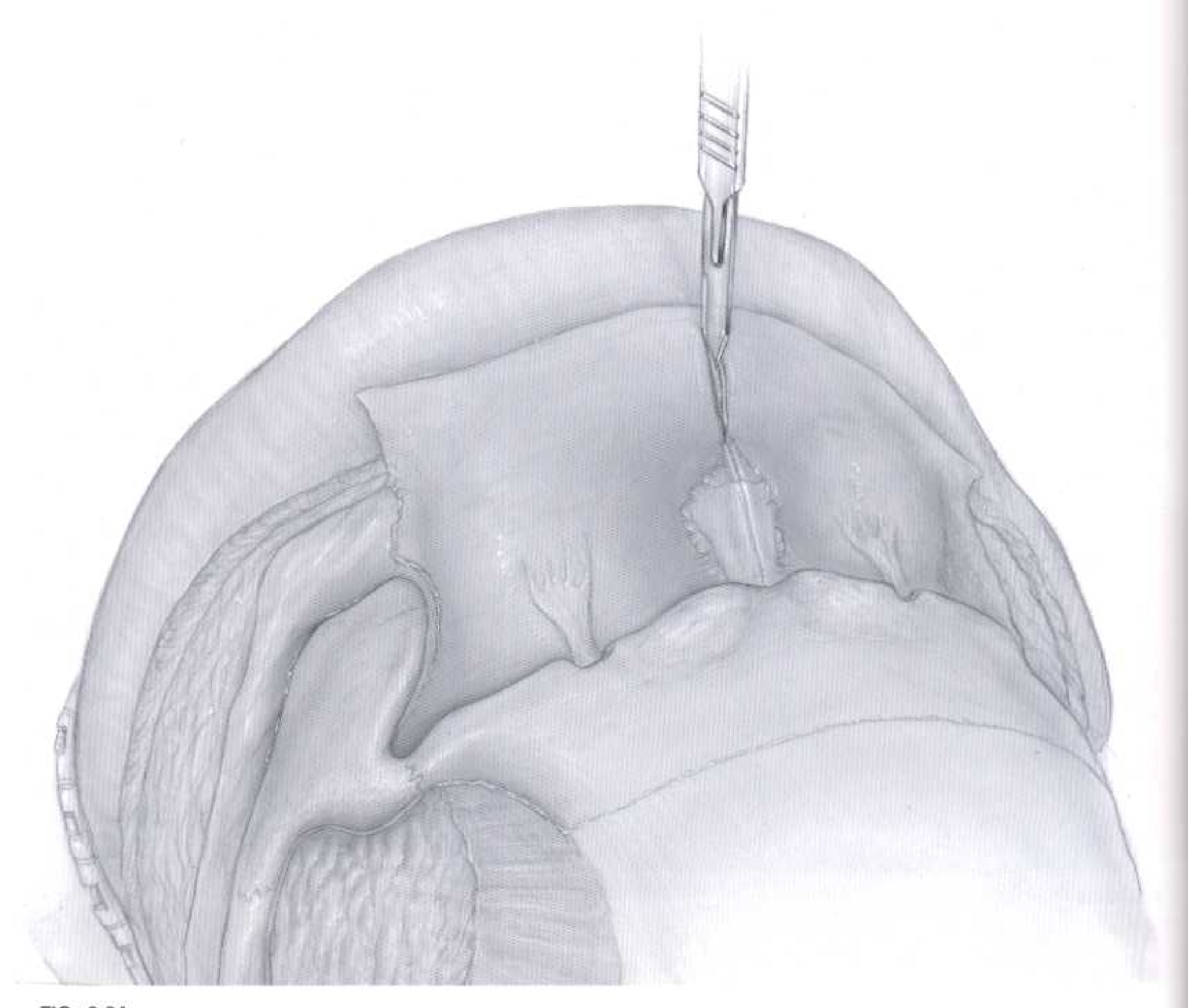


FIG. 3-34

The entire upper facial skeleton is exposed.

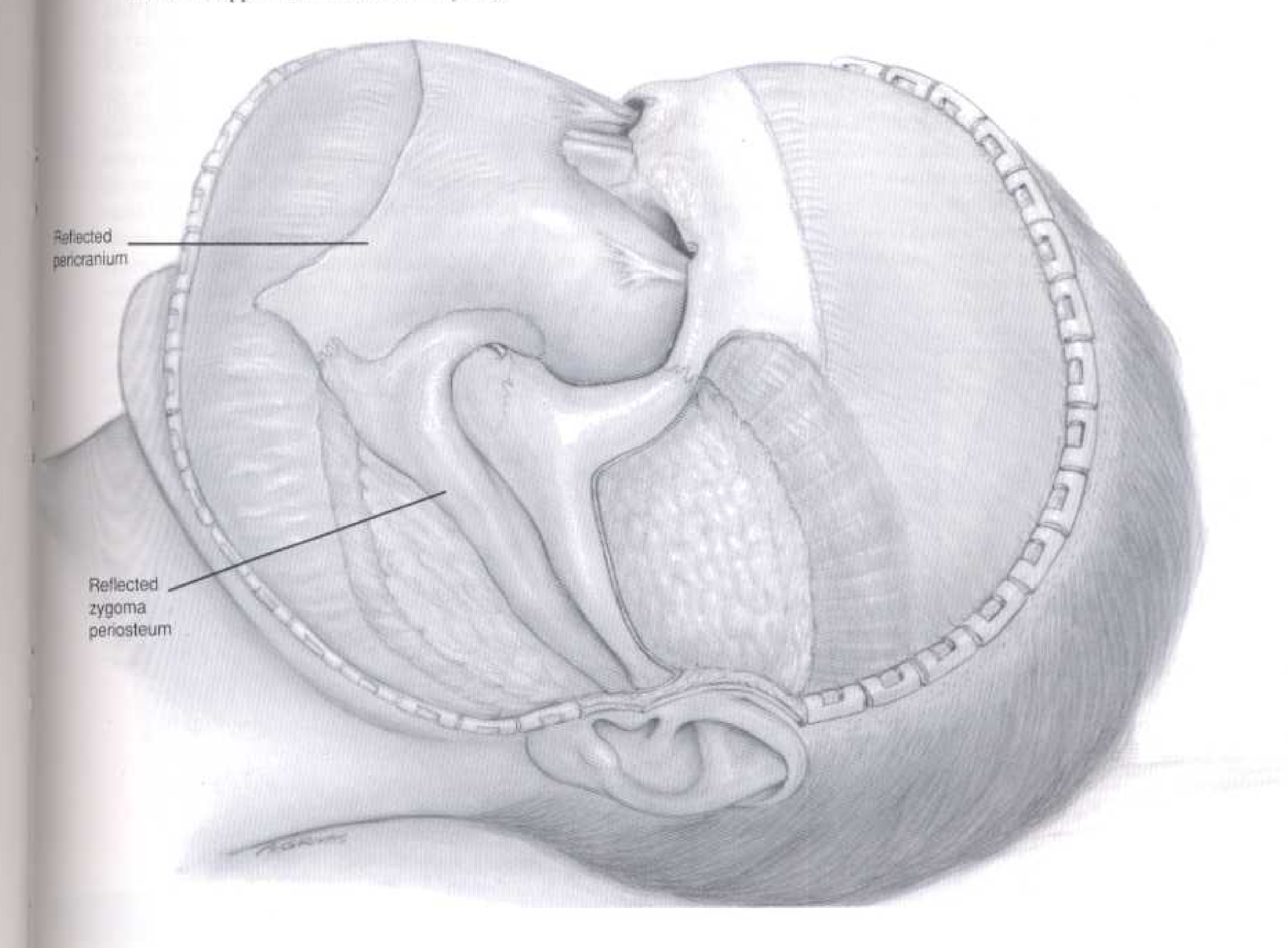


FIG. 3-35

Closure

At the completion of the procedure, the area is irrigated, and hemostasis is completed. If the medial and lateral canthal ligaments require reattachment, they should be secured at this time. Also, the temporal fascia should be resuspended to allow for proper soft tissue draping.

The scalp is then closed in a two-layer fashion, 3—0 resorbable suture of medium- to long-term duration is used to close the layer of the galea. This is followed by closure of the scalp with staples or suture, depending on the preference of the surgeon. A craniotomy type of dressing may be applied, and the choice of using a drain depends on the preference of the surgeon.

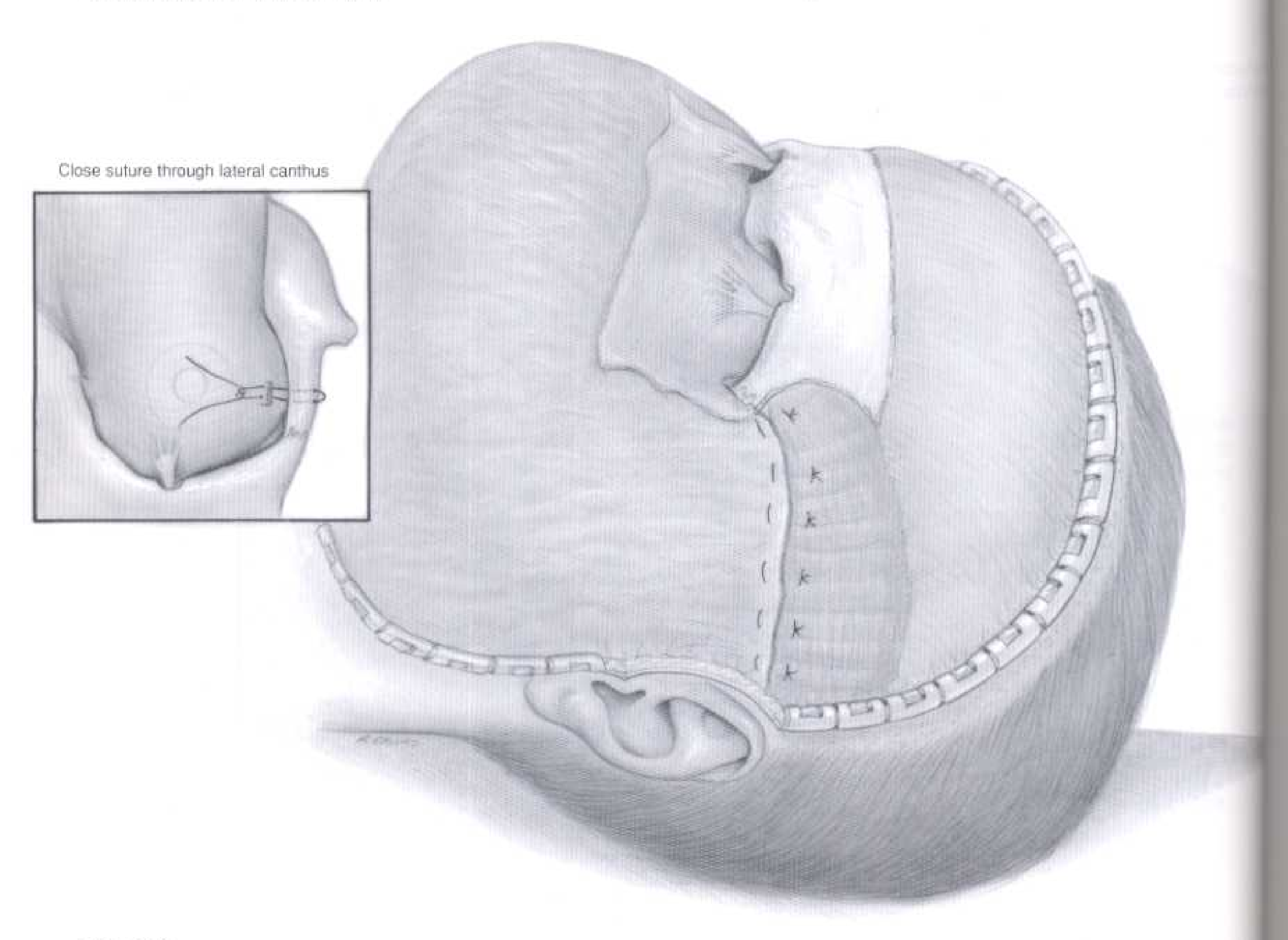


FIG. 3-36

SUBLABIAL

Introduction

The sublabial approach is one that rapidly exposes the lower half of the midface, extending from the maxillary dental arch inferiorly to the body of the zygoma laterally and medially to the nasal process of the maxilla and the inferior portion of the nasal bones. This also includes the infraorbital rim and the lateral and medial buttresses of the maxilla. The sublabial approach is indicated when approaching fractures and osteotomies that involve the maxilla at the Le Fort I and II level and hemimaxillary fractures, malar complex fractures, and medial maxillary fractures. Infection is an unusual complication, and a more common complication is wound dehiscence. Injury to the infraorbital nerve during the exposure of the upper portion of the maxilla is also a complication of this incision. Care must be taken when making the incision to allow for an adequate cuff of free mucosa for later closure and to avoid extending the incision too close to the gingival junction. If this occurs, as wound healing and scar contracture begins, the gingiva may be pulled superiorly, resulting in gingival recession and the possibility of exposed cementum or periodontal disease. With the patient asleep the oral cavity is thoroughly irrigated with saline. A sponge or toothbrush is used to brush the teeth and the entire oral mucosa thoroughly, including the buccal mucosa, tongue, palate, and the floor of mouth. The oral cavity is again irrigated, and the preparation may be repeated with a chlorhexidine gluconate mouth rinse. Severe calculus formation or periodontal disease may require preoperative cleaning and scaling of the teeth prior to beginning the actual procedure to reduce the possibility of contamination. The instrumentation commonly used includes Langenbeck retractors, periosteal elevators, and Fraser or similar small suction tips.

Technique

After the oral cavity has been prepared in accordance with the earlier guidelines, a right-angle retractor is inserted in each upper buccal sulcus, exposing the entire anterior face of the maxilla from tuberosity to tuberosity. The proposed incision site may be injected with a vasoconstricting agent. An initial incision is made in the mucosa from the maxillary first molar only to the maxillary first molar. This is carried only through the mucosa with the scalpel held at 90° to the mucosal bed. A second incision is made through the first, which goes through the submucosa and the periosteum down to the maxilla. This incision is made at right angles to the anterior face of the maxilla and the underlying bone posteriorly. Care must be taken to maintain at least a 7.0-mm cuff of free mucosa so that a two-layer everted closure can be achieved to prevent the gingiva from recessing during scar maturation.

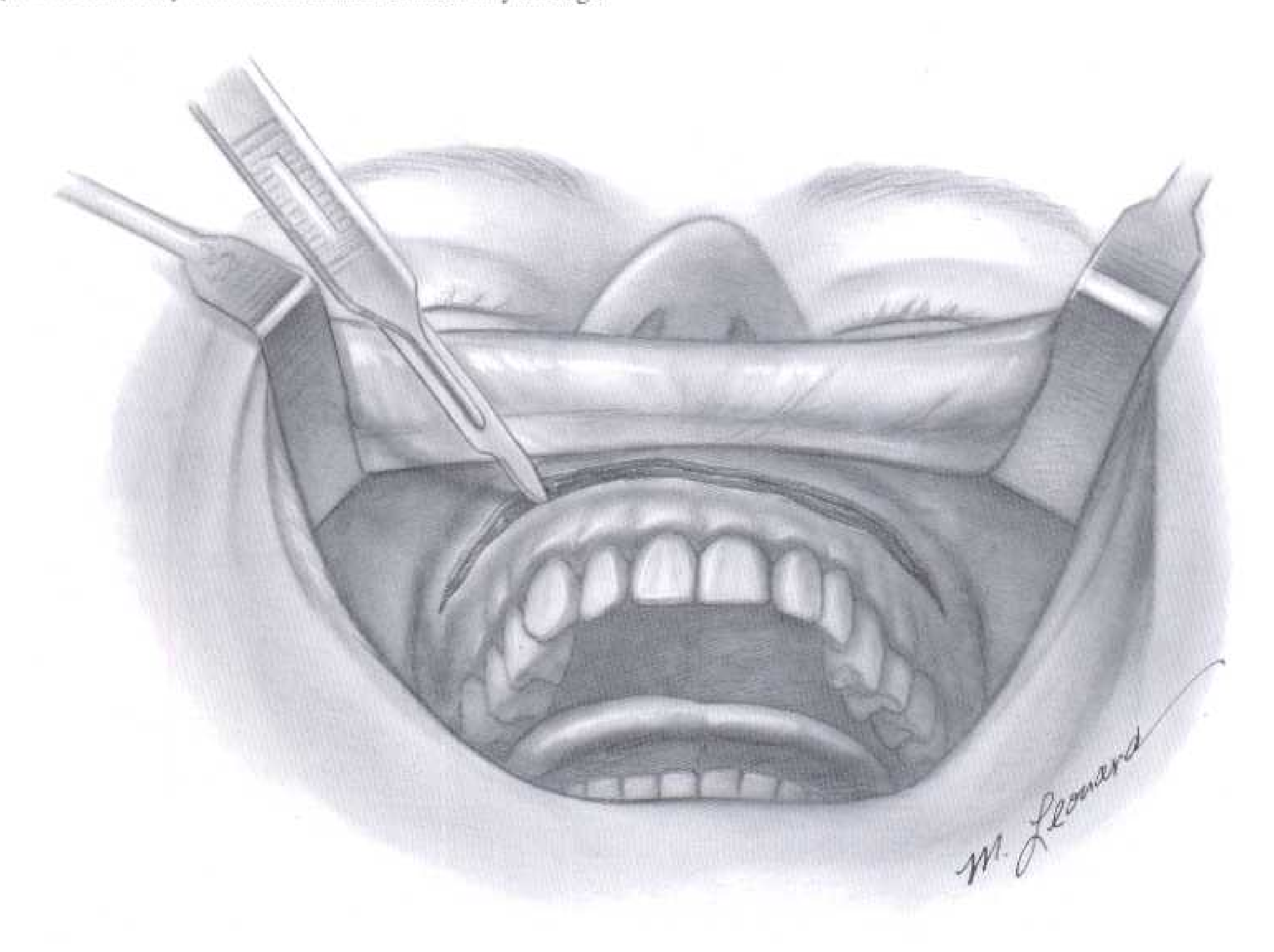


FIG. 3-37

Hemostasis may be appropriately achieved with cautery. If further posterior exposure is required, the incision may be carried back to the region of the second molar. However, if the incision is carried superiorly in this region, the buccal fat pad is encountered, which will herniate into the operative site.

In the one-hand suction technique, with an assistant holding a right-angle retractor to elevate the tissues of the lip and cheek, the surgeon uses a periosteal elevator in one hand and a suction tip in the other to elevate the tissues of the midface. Dissection is performed in a subperiosteal plane, extending from the piriform aperture to the lateral buttress. Medially, the dissection is carried superiorly to the level of the infraorbital nerve, which is identified and preserved. If necessary, the elevation may proceed superiorly along the medial buttress, exposing the infraorbital rim, nasal process of the maxilla, and the inferior portion of the nasal bones. Lateral to the infraorbital rim, the dissection continues superiorly over the malar prominence to the level of the lateral canthus and laterally over the body of the zygoma.

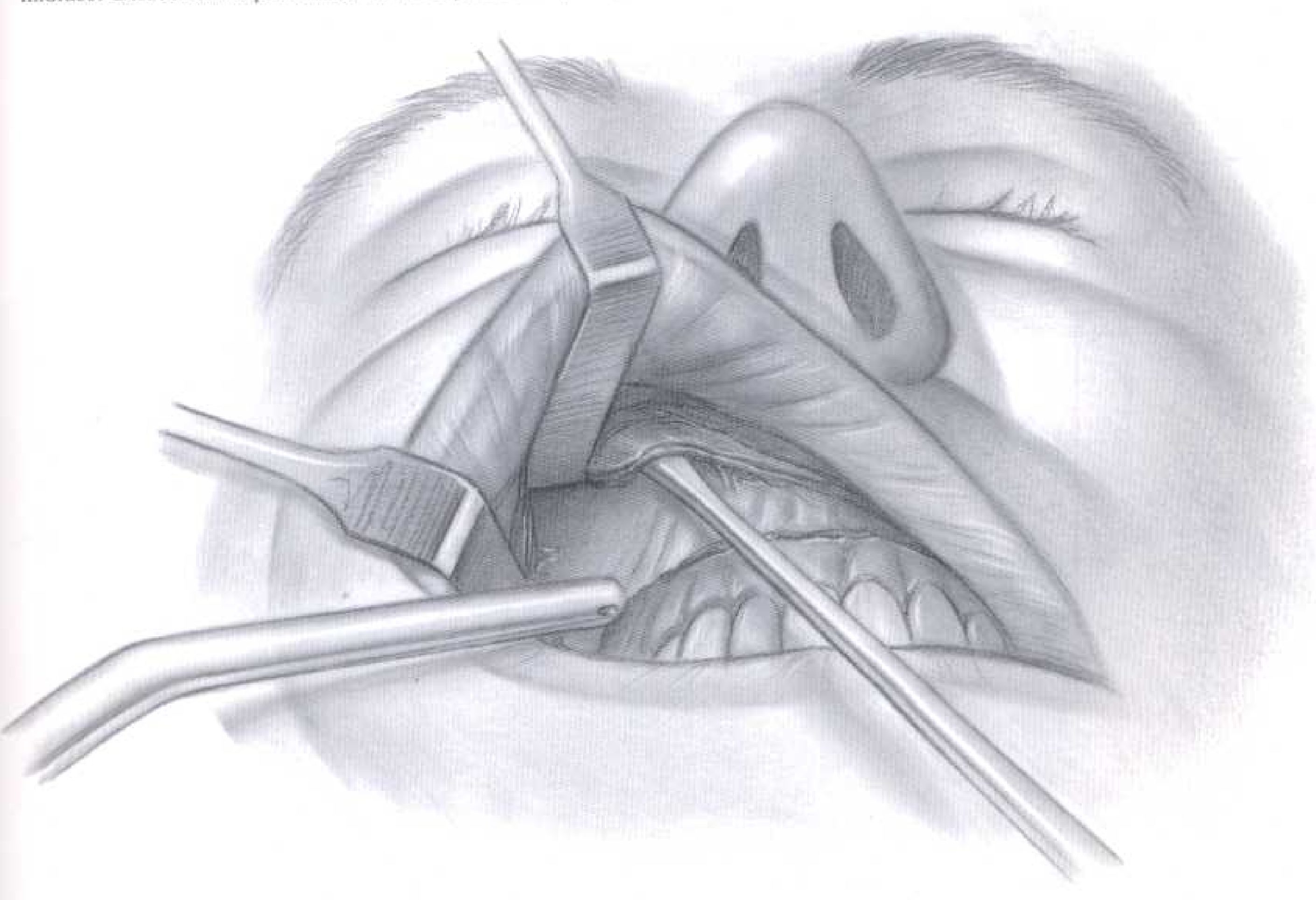


FIG. 3-38

In the two-hand technique, the surgeon is seated at the patient's head with an assistant holding the retractor parallel to the lip and the buccal soft tissues. A second assistant sitting on the surgeon's right side holds the suction tip, and the surgeon holds a periosteal elevator in each hand. Rather than a pushing motion, as in the one-hand suction technique, the surgeon uses the elevators in a scraping technique, pulling the soft tissues free from the bone in a subperiosteal plane from inferiorly to superiorly toward the head. The same degree of exposure is obtained with the one-hand suction technique; however, the dissection with the two-hand technique proceeds more rapidly than with the one-hand suction technique. Two assistants are required, however, to perform the two-hand technique.

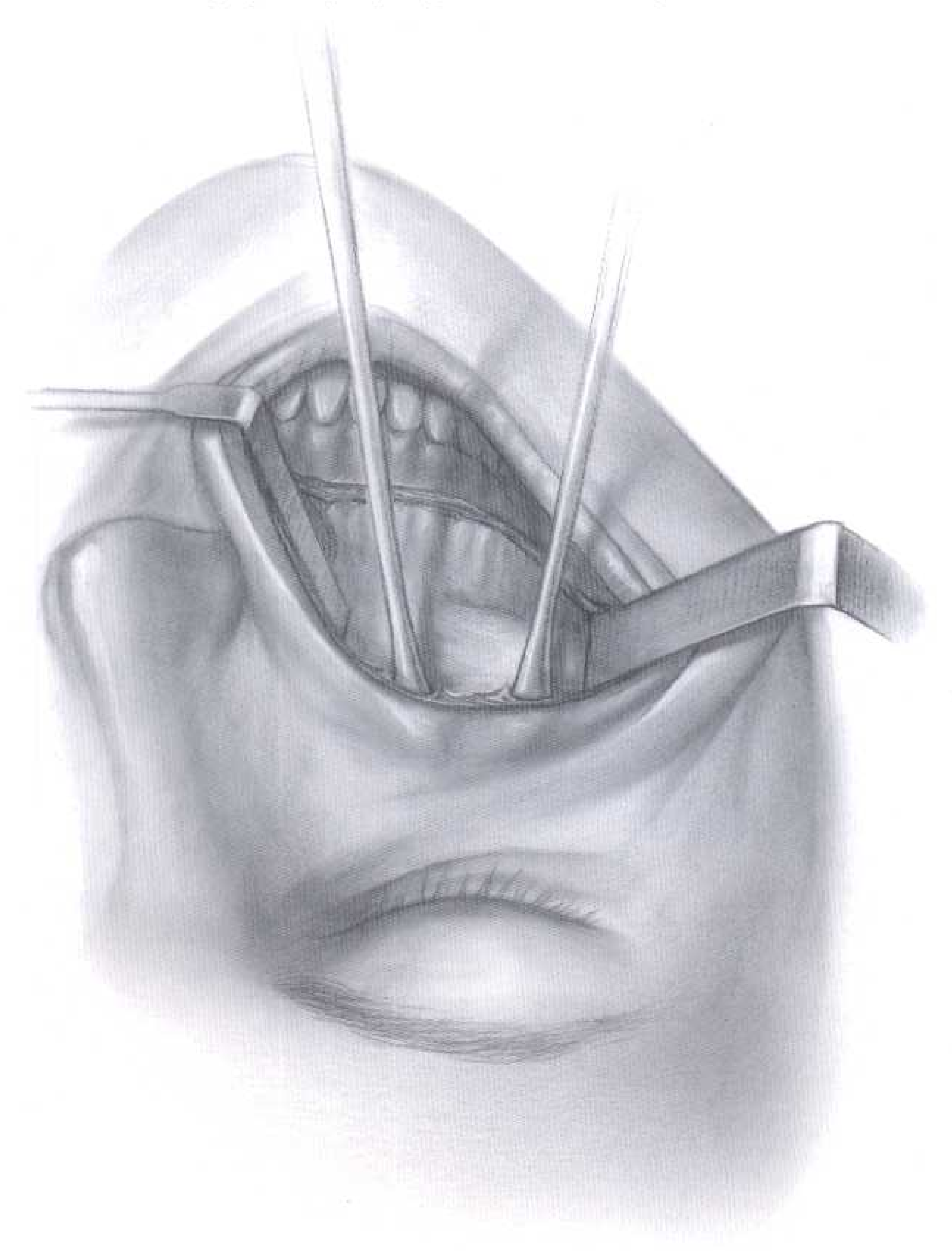


FIG. 3-39

If necessary, the piriform aperture and floor of the nose may be skeletonized by using a right-angle Freer elevator to dissect over the piriform aperture and along the floor of the nose and then along the inferior meatus elevating the mucosa from the underlying bone.

The dissection of the lateral buttress proceeds in a subperiosteal fashion. If necessary, the incision may be lengthened to provide more direct exposure in this area and, in particular, to the pterygomaxillary fissure. If the incision extends superiorly in the region of the second molar, the buccal fat pad may be encountered, which may then herniate into the operative field.

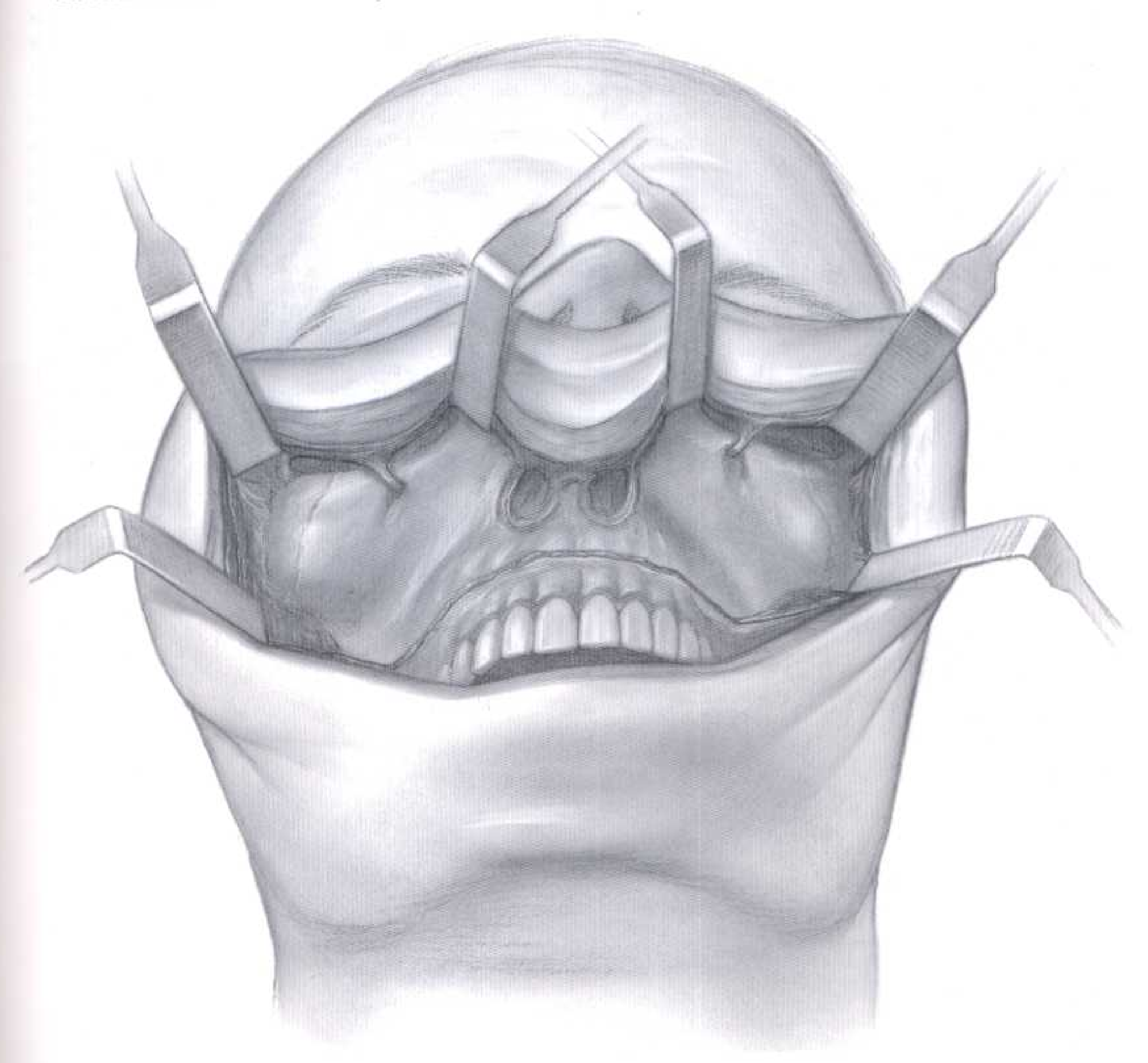


FIG. 3-40

Closure

Prior to definitive closure, hemostasis must be achieved. The mucosa is then undermined in the submucosal plane for approximately 3 to 5 mm. This is done only on the lip and buccal soft tissue side of the incision and not on the mucosa and gingiva side of it. This is done with a scalpel and a skin hook, not with forceps. After the undermining has been complete (which allows for eversion of the soft tissues on closure), the wound is then closed in two layers. A submucosal periosteal suture is placed with material of the surgeon's preference (gauge, 2—0 or 3—0). This is fashioned through these layers in a continuous horizontal mattress suture, beginning from the midline and extending out laterally. This ensures the correct position of the soft tissues of the midface in relation to the underlying bone. The second layer uses a 4—0 suture, which is then used to close the mucosa that has been everted. Only the mucosal edges are approximated with this suture in a simple continuous fashion.

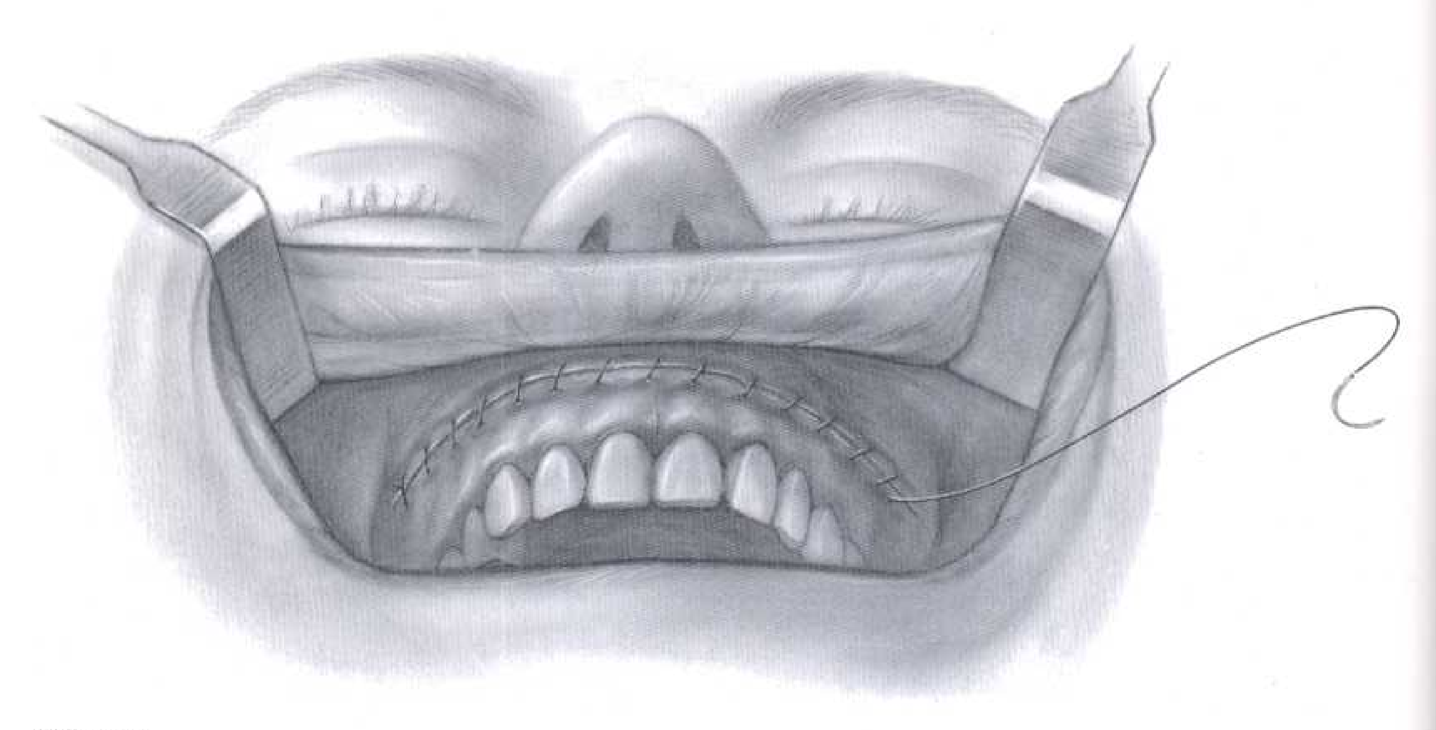


FIG. 3-41

TRANSCONJUNCTIVAL/LATERAL CANTHOTOMY

Introduction

The transconjunctival lateral canthotomy approach provides wide exposure to the orbital floor, lateral orbital wall, infraorbital rim, and lateral orbital rim up to approximately 1.0 cm above the frontozygomatic suture. This approach is indicated in addressing fractures in these areas. The complication rate is low; however, blunting of the lateral canthus and entropion may occur. These problems are eliminated during the closure by approximating the cut edge of the tarsal plate to the lateral canthus with a semipermanent suture. The periorbital area is prepared in the usual fashion with precautions to avoid getting the preparation solution into the eye. A corneal shield may be used at the discretion of the surgeon. The instrumentation includes a number 15 scalpel blade, Westcott scissors, Desmarres retractor, and two or more 0.5-mm forceps. A Castroviejo needle holder is convenient at the time of the closure.

Technique

The proposed incision sites may be injected with a vasoconstricting agent. If a lateral canthotony is to be performed, an incision is made in the skin through the lateral canthus, which extends laterally to 5 to 10 mm onto the facial skin. This is placed through a skin line and extends through the skin and subcutaneous tissues to the musculus orbicularis oculi. At this point, a small artery is usually encountered near the lateral canthus. This may be cauterized using bipolar, heat, or monopolar cautery. Fine scissors are used to incise the lower half of the lateral canthus.



FIG. 3-42

In the preseptal approach, following the lateral skin incision, the lateral portion of the lower lid is everted easily by using the 0.5-mm. Castroviejo forceps. Wescott scissors are used to incise the orbital septum approximately 5.0 mm inferior to the tarsal plate. A preseptal tunnel is created with the scissors. With one blade placed in the tunnel and the other blade over the conjunctiva, the orbital septum is sectioned by the scissors. This dissection is carried medially to a distance no closer than 5.0 mm to the lacrimal puncta (Fig. 42B and C).



FIG. 3-43

After the incision is complete, the dissection is carried in the plane between the orbital septum and the musculus orbicularis oculi. The dissection is carried down to the orbital rim for the entire incision. Care is taken to preserve the infraorbital nerve.

An incision is made on the facial side of the infraorbital rim periosteum above the infraorbital nerve. Using a periosteal elevator of appropriate size, a subperiosteal dissection is then performed to expose the orbital floor.

If exposure is needed to the lateral orbital wall and the frontozygomatic suture, the subperiosteal dissection then continues laterally and superiorly in these areas to expose the operative site.

In the postseptal approach, following completion of the lateral canthotomy and the facial skin incision, the lower lid is everted with the use of 0.5-mm. Castroviejo forceps. The infraorbital rim is palpated, and an incision is made through the conjunctiva and the lower lid retractors down to the infraorbital rim. Following the incision, a subperiosteal dissection is then used to expose the orbital floor. If the lateral orbital wall and lateral orbital rim also require exposure, the subperiosteal dissection continues in this fashion. Orbital fat is encountered as the dissection continues around the rim and laterally in the postseptal plane.

In the frontozygomatic suture dissection, whether the pre- or postseptal approach has been used, if the frontozygomatic suture requires exposure, the dissection is continued laterally along the lateral orbital rim and then superiorly to a distance of approximately 1.0 cm above the frontozygomatic suture. This is accomplished directly by using a Freer type of periosteal elevator and either a small Langenbeck retractor or a Senn retractor.

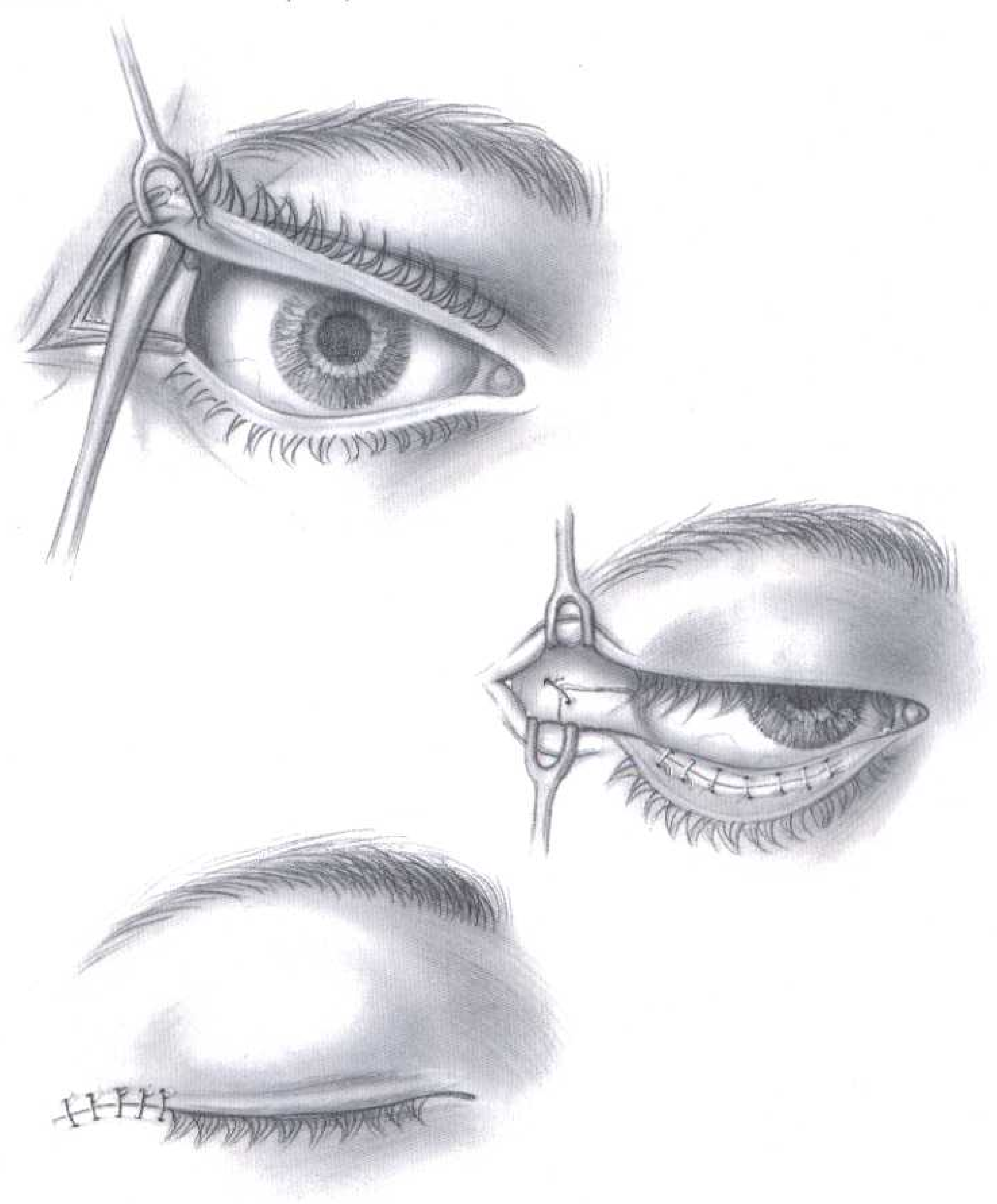


FIG. 3-44

Closure

The conjunctiva may be closed with a 6—0 chromic buried knot suture starting medially and continuing laterally to the area of the canthotomy. Some surgeons prefer not to close the conjunctival incision.

A long-lasting suture material is used to secure the tarsal plate to the lateral canthus. The lower lid is grasped with the 0.5-mm Castroviejo forceps, and a suture is placed through the lateral aspects of the cut tarsal plate. The suture is then placed through the lateral canthal ligament posteriorly to the lateral orbital rim attachment so that, by tightening the suture, the lid is pulled up and in.

The subcutaneous and deep layers of the facial skin incision are closed, and the skin may be approximated with either suture material or strip adhesive, depending on the surgeon's preference.

SUBCILIARY

Introduction

The subciliary approach can provide wide exposure to the infraorbital rim, orbital floor, lateral orbital rim and wall, and frontozygomatic suture. It is indicated when approaching fractures involving these areas. The approach has a fairly low complication rate; however, ectropion, particularly in a severely traumatized patient, may result. The degree of periorbital soft tissue injury dictates whether this approach should be used or not. The periorbital area is prepared in the usual fashion, taking care to avoid introducing the preparation solution into the eye. A corneal shield may be used. The instrumentation for this approach is identical to that for a blepharoplasty, and the small fine-point scissors, small forceps, and skin hooks, along with bipolar cautery, are the instruments of choice.

Technique

A vasoconstricting agent, depending on the surgeon's preference, may be injected into the proposed incision site. The incision is made in the region of the lateral canthus laterally for 5 to 10 mm on the facial skin. This is carried down through the skin and subcutaneous tissues to the level of the musculus orbicularis oculi. The incision is then carried medially below the lashes, approximately 2 to 3 mm, to extend to approximately 5 mm lateral to the lacrimal punctum. The incision may be made through the skin and the muscles with a fine scalpel blade, or a tunnel may be created laterally by using the fine-point scissors and the blades of the scissors and then creating an incision both through the skin and the underlying muscle.

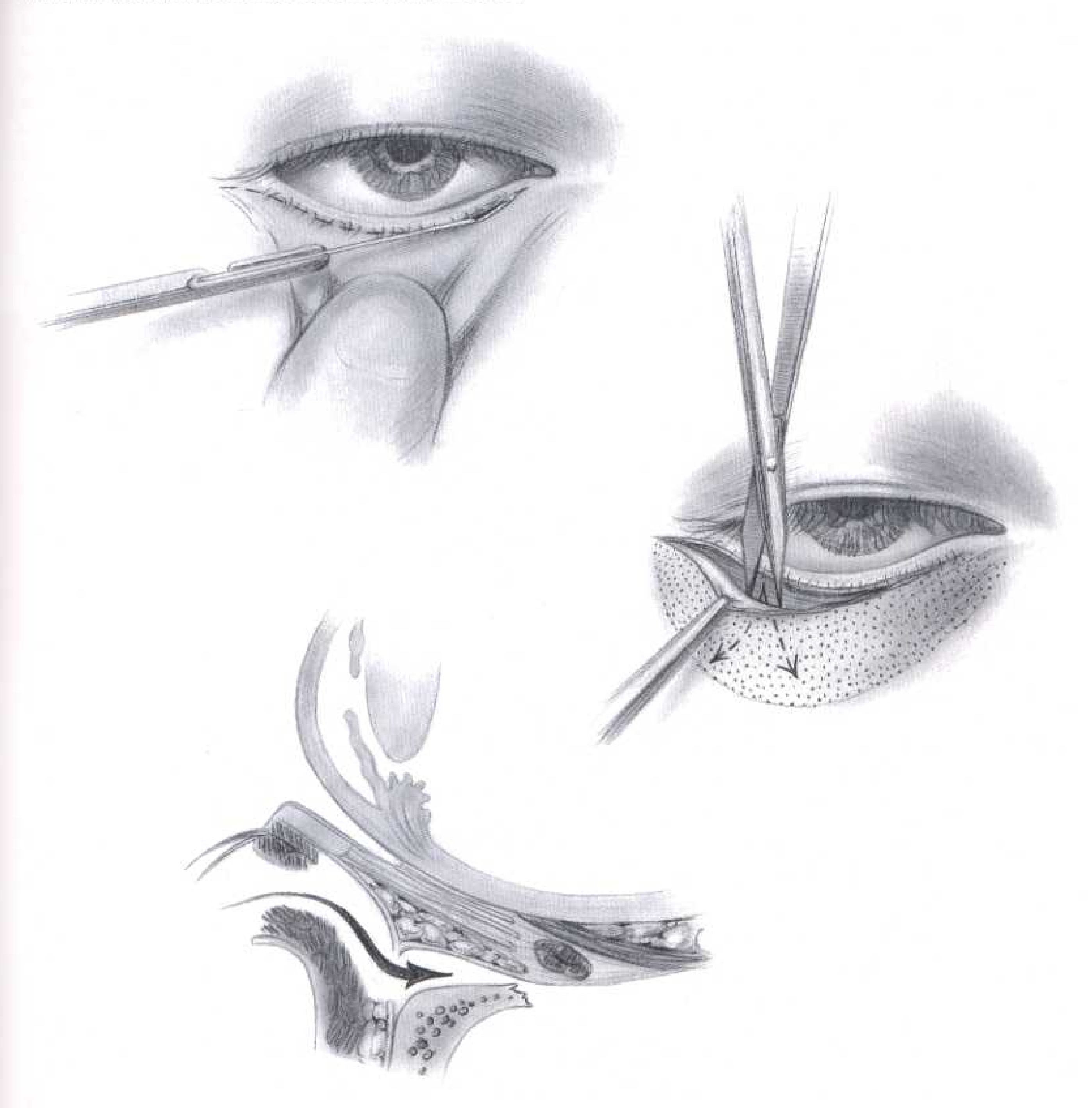


FIG. 3-45

A skin—muscle flap is developed in the plane between the orbicularis oculi fibers and the orbital septum. This dissection is carried in this plane down to the infraorbital rim. If there is bleeding on the orbital septal side of the dissection, caution must be exercised because monopolar cautery may penetrate through the orbital septum and conjunctiva and cause corneal damage.

After the orbital rim has been identified, an incision is made on the facial side of the rim through the periosteum and above the infraorbital nerve.

Using a subperiosteal elevator of appropriate size, subperiosteal dissection is used to dissect the orbital floor.



FIG. 3-46

If an approach is required to the frontozygomatic suture, the inferior orbital rim periosteal incision may be extended laterally and superiorly along the rim to the frontozygomatic suture with the overlying skin retracted. A periosteal elevator of appropriate size is used to create a subperiosteal dissection to the lateral frontozygomatic suture.

Closure

The skin—muscle flap is laid back into position. A tacking suture is used from the area of the lateral canthus to that portion of the skin—muscle flap directly overlying the canthus. After this is tightened, the skin may then be closed with either adhesive strips or a suture material of the surgeon's preference.

INFRAORBITAL RIM APPROACH

Introduction

The infraorbital rim approach provides exposure to the orbital floor, particularly in the medial portion of the orbit. It is indicated in patients in whom exposure is needed to the infraorbital rim and the floor of the orbit. It has a relatively low complication rate. Ectropion, however, can occur if deep sutures are placed to reapproximate the septum to the infraorbital rim, thus everting the lower lid. The periorbital area is prepared with a preparation solution of the surgeon's choice; care is taken to avoid introducing the preparation solution into the eye. A corneal shield may be used at the discretion of the surgeon. Fine facial plastic instruments are needed for this approach, including a small fine-tipped scissors, skin hooks, and the 0.5-mm Castroviejo forceps.

Technique

If the surgeon prefers, a vasoconstricting agent may be injected at the proposed incision site. An incision is then made in the skin of the infraorbital area in a skin crease. The incision follows the inferior lateral arc of the skin crease and should extend to no more than the lateral limbus of the pupil. Extension beyond this point increases the risk of lymphedema of the lower lid postoperatively.

After the incision is made through the skin and subcutaneous tissues, the dissection then proceeds down to the orbital rim, bluntly or sharply dissecting in the direction of the orbicularis oculi fibers. After the rim is identified, the periosteum of the infraorbital rim is incised on the facial side of the rim superior to the infraorbital nerve. After the periosteal incision is created, a periosteal elevator of appropriate size is used to perform a subperiosteal dissection of the infraorbital rim and orbital floor.

Closure

The subcutaneous muscle layers may be closed with an absorbable suture of the surgeon's preference. The skin may be closed either with suture material or sterile adhesive closure.

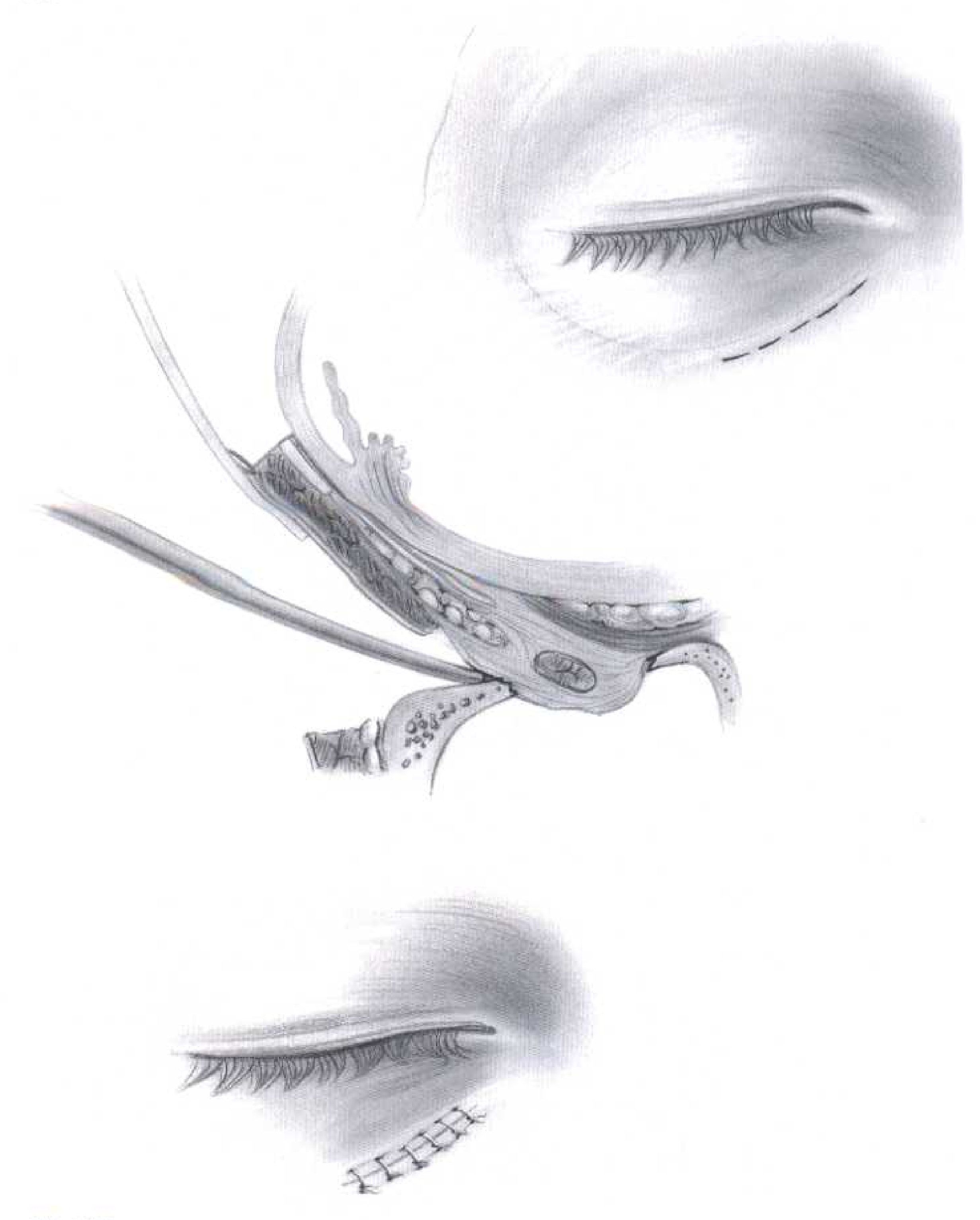


FIG. 3-47

BROW INCISION

Introduction

The brow incision provides adequate exposure to the frontozygomatic suture. It is indicated when exposure of this area is required for fracture fixation. It has an extremely low complication rate, with the most common one being widening of the scar. The periorbital area is prepared in the standard fashion with an antiseptic preparation solution; care is taken to avoid introducing the preparation solution into the eye. A fine scalpel, a fine-tipped mosquito hemostat, Senn retractors, and a periosteal elevator are required for the approach.

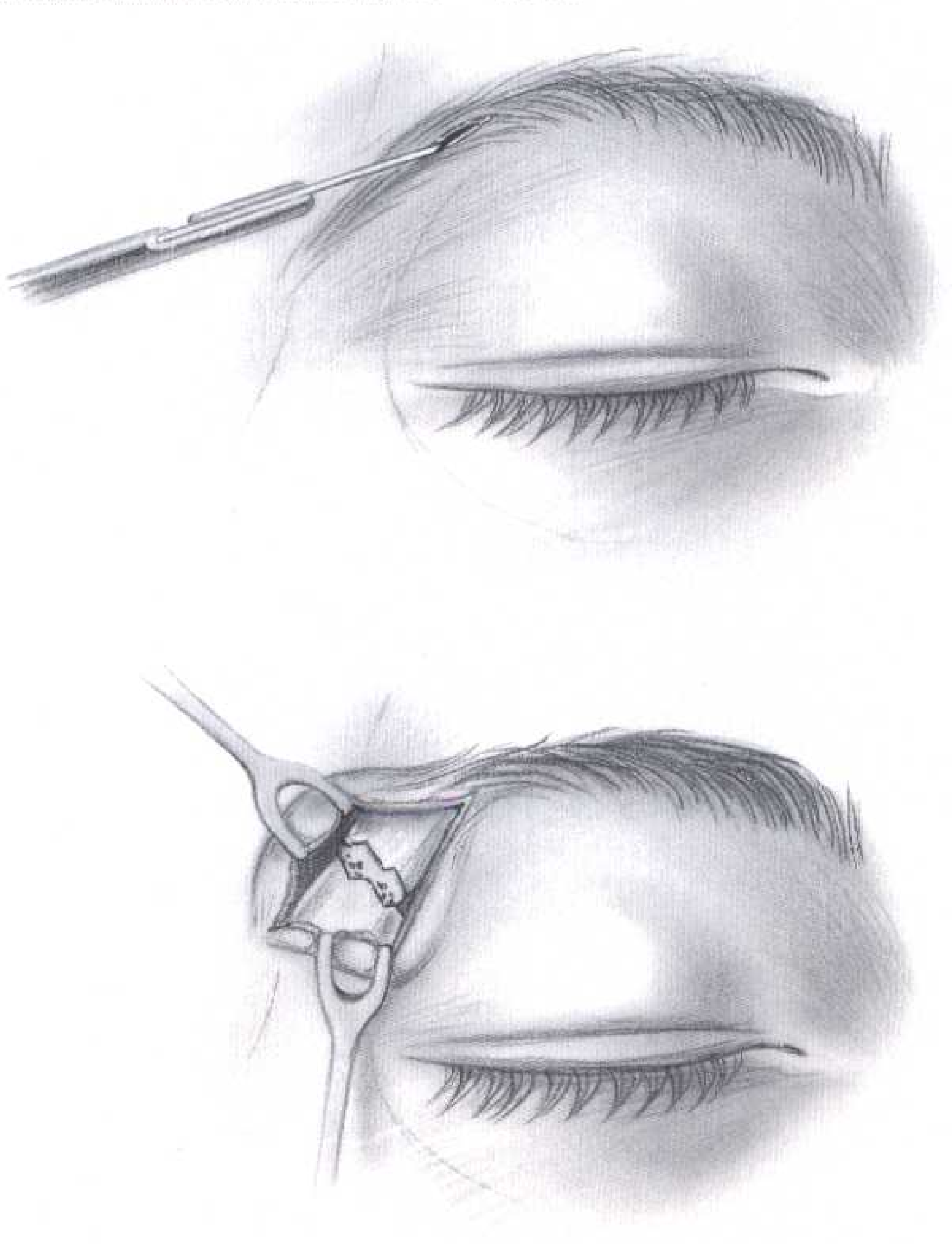


FIG. 3-48

Technique

The operative site may be injected with a vasoconstrictor if the surgeon prefers. An incision is made through the facial skin parallel to the hair shafts at the superior border of the lateral brow overlying the frontozygomatic suture. This aids in minimizing widening of the scar and damage to underlying hair follicles. After the incision is completed through the skin and the subcutaneous tissues, a fine-point mosquito hemostat is used to dissect the muscle fibers bluntly down to the periosteum. Sharp dissection may be used here; however, a small branch of the facial nerve that innervates the orbicularis oculi medial to the incision may be injured. After exposure of the periosteum, the periosteum is incised, and a periosteal elevator of appropriate size is used to expose the frontozygomatic suture. Senn retractors are used to retract the skin and the muscle fibers.

Closure

A subcutaneous suture closure is performed. The skin may then be closed with either a suture closure or a sterile adhesive closure.

UPPER LID BLEPHAROPLASTY APPROACH

Introduction

The upper lid blepharoplasty approach has gained popularity because of its good cosmetic result and excellent access to the frontozygomatic suture. It is placed in an upper lid skin crease and, when it heals, it blends with the supratarsal fold. The complication rate is low if the correct technique is followed. The instruments used are fine tipped scissors, 0.5 mm. Castroviejo forceps, and bipolar cautery.

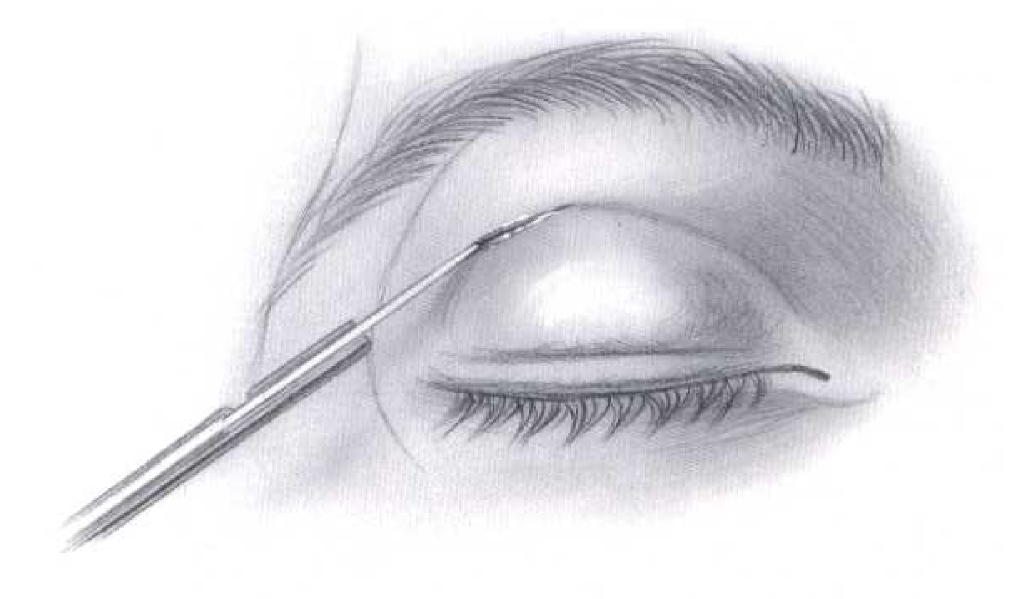
Technique

The operative site may be injected with a vasoconstrictor. An incision is made through the skin of the upper lid from mid pupil to the lateral orbital rim. Hemostasis is achieved with bipolar cautery. Monopolar cautery should not be used as injury can occur to the underlying sclera from thermal conduction (Fig. 3-49A).

The incision is continued through the orbicularis occuli so as to develop a skin-muscle flap, and the dissection is continued superiorly and laterally toward the frontozygomatic suture. Using fine retractors or skin hooks, the incision is retracted laterally over the suture, the periosteum at the suture is incised, and the fracture site is exposed (Fig. 3-49B).

Closure

The periosteum is closed with fine absorbable suture. The skin incision is closed with either fine suture or sterile adhesive strips.



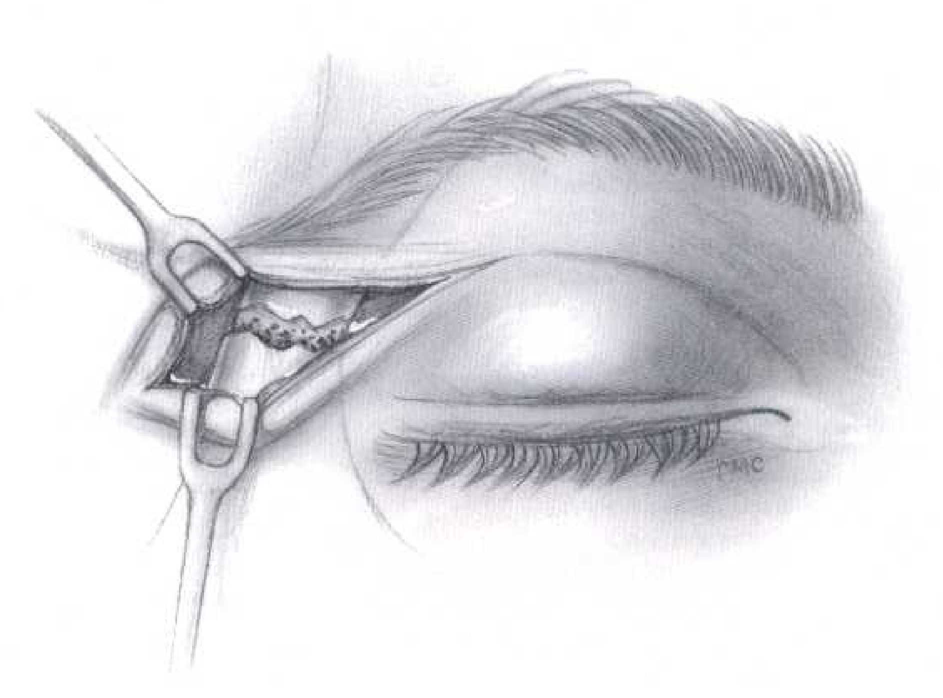


FIG. 3-49

UNIT IV

Bone Graft Harvesting Techniques

UNIT OUTLINE

CHAPTER 1

Calvarial Bone Grafts

OUTER TABLE CALVARIAL BONE GRAFTS

In recent years, outer table calvarium has become a popular source of membranous bone for grafting. Although it is generally rigid and strong, it may be harvested as a soft pliable graft by using a specially designed osteotome similar to a gouge. As the thin layer of outer table is harvested, microfractures are created that make the graft soft. The graft may be easily contoured during the course of harvesting. When harvested in this way, however, the graft is weak, and it will not provide support for reconstructing bony defects in which strength is needed, such as the maxillary buttresses.

For solid bone, the outer table calvarium is harvested as a single graft with the cortical layer intact. This results in a rigid graft that may be used to reconstruct stress areas. Because this solid bone cannot be bent to shape, the contour of the recipient site must be carefully determined so that the contour (curvature) of the donor bone is well matched to that of the recipient site.



FIG. 4-1

Grafts harvested in an anteroposterior direction are straighter and, therefore, are best suited for the reconstruction of the medial buttresses and nasal dorsum. Grafts oriented in a superoinferior direction along the lateral skull are more curved and, therefore, are generally better suited for reconstruction of the lateral buttresses and zygomas. The donor site should be located on the parietal bone between the temporal line and a point 1.5 cm lateral to the sagittal suture. The bone below the temporal line is too thin to allow for safe harvesting of the graft. It is crucial to avoid the midline because the sagittal sinus is located beneath the sagittal suture, and inadvertent penetration of the inner table during graft harvest could result in laceration of the sinus, which could result in significant bleeding and possibly air embolism and/or sinus thrombosis.

Surgical Technique

The donor site is exposed either through a bicoronal incision, or if this is not necessary, through an incision placed directly over the proposed donor site. If a relatively straight graft is required, the graft will be harvested in an anteroposterior direction. If a curved graft is required, this will be harvested in a superoinferior (medial to lateral) direction. After the donor site is exposed, the size of the graft is outlined.

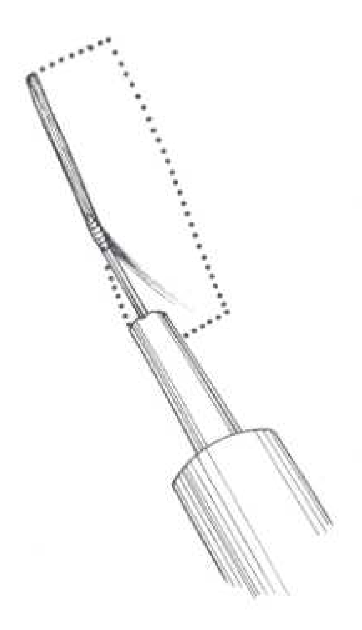


FIG. 4-2

The periphery is then drilled with a side-cutting burr, initially scoring the outer table until the graft is circumscribed. Outlining of the graft is continued until bleeding is noted coming from the depth of the bony cuts. This indicates penetration into the diploic layer. The graft is typically 2- to 3-mm thick at this point.

Using a rotating burr, the bone surrounding the graft along one long edge is drilled away to the diploë, feathering the edge so that a space of approximately 1 cm is created next to the donor bone.

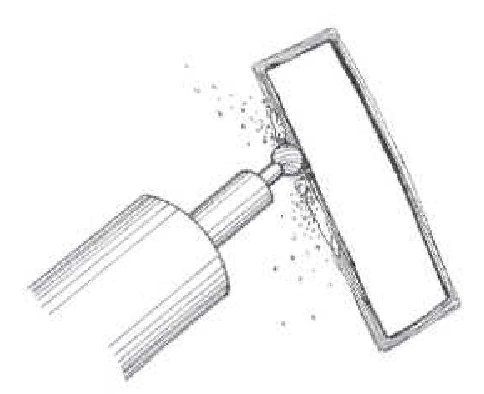


FIG. 4-3

This will allow insertion of the right-angle blade of the sagittal saw.

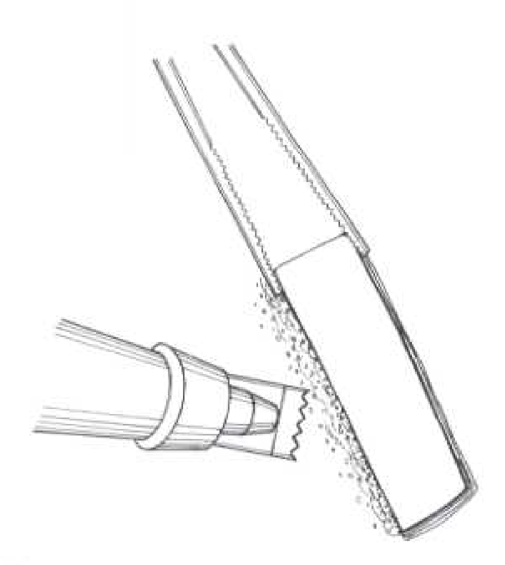


FIG. 4-4

If a graft wider than the length of the saw blade is needed, then this feathering drilling can also be repeated along the long edge on the opposite side of the proposed graft so that the saw blade can be used from both sides, thus doubling the width of the graft. Note, therefore, that if this saw is the only instrument used to section the diploic layer, then the width of the graft cannot exceed two times the length of the saw blade.

After feathering of the edges has been completed, the right-angle blade of the sagittal saw is introduced into the diploic layer between the intended graft and the underlying inner table bone. The saw is used to section the diploic bone, thereby freeing the graft from the inner table bone of the donor bed.

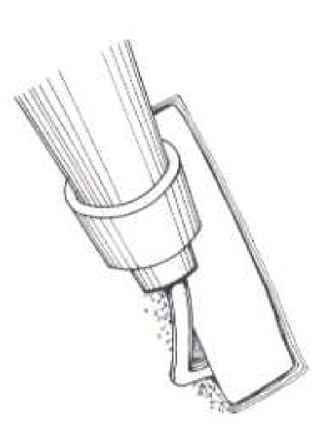


FIG. 4-5A

Care must be taken to keep the blade absolutely parallel to the surface of the outer cortex.

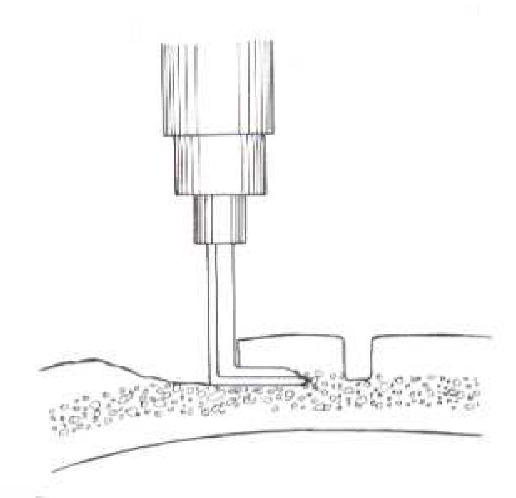


FIG. 4-5B

Otherwise, if the blade is turned upward, the resultant graft will be too thin. More commonly, if the blade is angled inward, the inner table may be penetrated, and a dural laceration and cerebrospinal fluid leak may result.

When the sectioning of the diploic layer is completed, the graft is grasped with a forceps and lifted from the donor site, taking care to grasp it before it falls from the field.

Another alternative is to use a straight reciprocating saw blade to harvest the outer table graft. The use of this blade requires drilling out the outer cortex around the entire proposed graft. The saw blade is then bent to conform to the shape of the skull and placed in the diploic layer.



FIG. 4-6

It is then used to section free the outer table from the inner table. Using this technique, larger grafts may be safely obtained. As in the sagittal saw technique, care must be used to keep the blade parallel to the curvature of the skull to avoid thinning of the graft or penetration of the inner table.

If a wider graft is needed, another alternative is to use an osteotome technique. As in the other techniques, the graft is first sharply outlined, cutting through the outer cortex until the bleeding diploic bone is entered. A 1-cm feathering drilling is then performed along one side of the graft, usually a short side. The osteotome is then driven under the full length of the donor bone, lifting the outer table graft off the inner table bone.

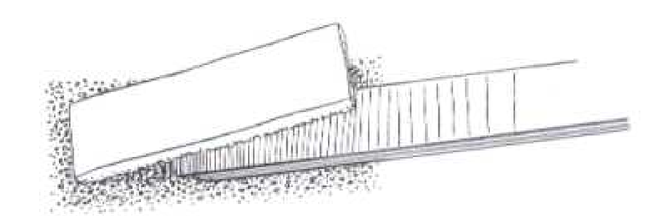


FIG. 4-7

Thus, the size of the graft is not limited by the size of a saw blade.

When the osteotome technique is used, a thin osteotome is recommended because it can be easily controlled. It is kept parallel to the outer cortex and advanced slowly. Care must be taken to avoid inner table fracture or splintering of the outer table graft. However, graft fracture is preferable to inner table penetration.

Donor site bleeding may be controlled by using either bone wax or a collagen resorbable sponge. Note that, during harvesting, venous lakes may be encountered in the diploic layer that produce significant bleeding. If this occurs early during the harvesting of the graft, then bone wax is placed at the edges of the graft to control the bleeding, and another donor site is chosen. However, if a venous lake is encountered during the diploic sectioning portion of the procedure, then the saw cuts are finished as quickly as possible, the graft is removed, and immediate hemostasis is accomplished by using bone wax.

INNER TABLE CALVARIAL BONE GRAFTS

Inner table calvarial bone grafts have the advantage of providing a large amount of donor bone without leaving a cosmetic defect in the calvarium. Inner table grafts are most commonly harvested when intracranial—extracranial procedures are being performed. The grafts are harvested from the inner table of the craniotomy bone flap while the flap is out of the patient.

Surgical Technique

The craniotomy bone flap has been removed, and the size of graft needed has been determined to meet the need of the recipient site defect. For harvesting the inner table graft from the double-layered bone flap, an oscillating, sagittal, or reciprocating saw may be used. After outlining the graft on the inner table, the diploic layer is entered, and using the saw, it is sectioned in its entirety, thereby freeing the inner table bone from the craniotomy bone flap.

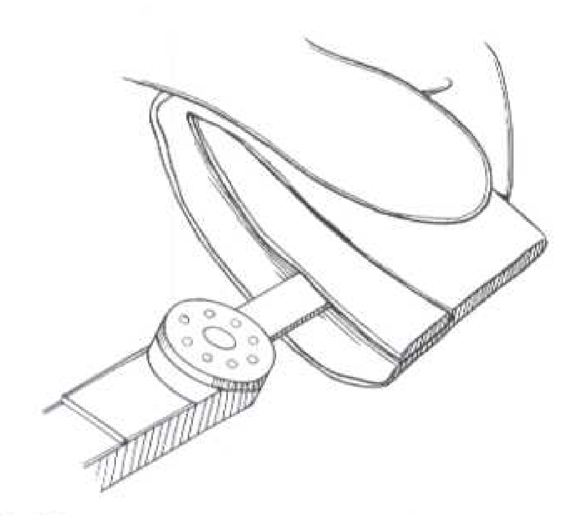


FIG. 4-8

Alternatively, an osteotome may be used in lieu of the saw blade. However, it must be flexible enough to be able to follow the contours of the inner table. Otherwise, fractures of the graft or penetration of the outer table may occur, and excessive thickness of the graft may result.

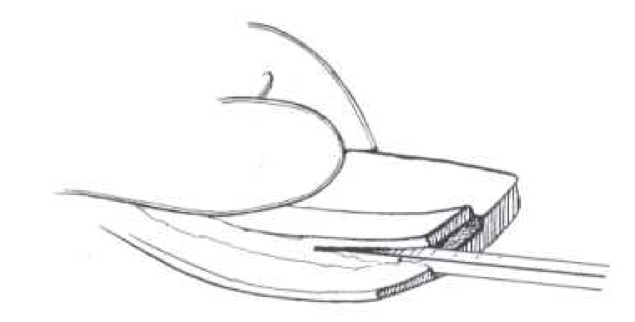


FIG. 4-9A

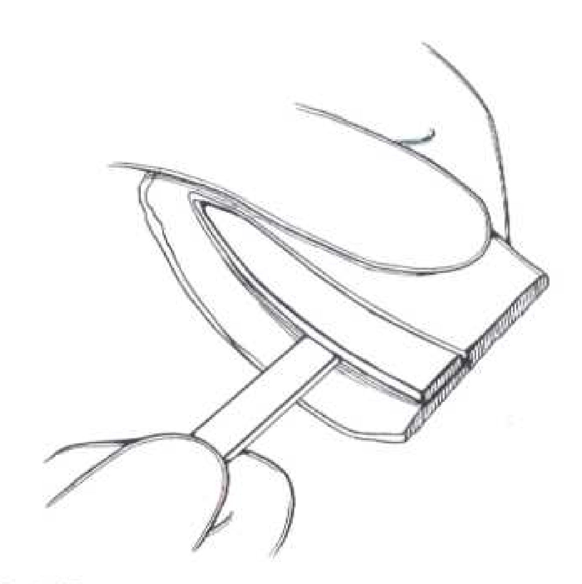


FIG. 4-9B

Following the diploic sectioning with either the saw or the osteotome, a wide osteotome is inserted into the diploic layer for final removal of the graft.

CHAPTER 2

Rib Grafts

Split rib grafting has been available for many years. Rib bone is available in large quantities, and it can be contoured precisely to the shape of the recipient bed. Rib grafts have the disadvantage, however, of undergoing varying degrees of bone resorption during the postoperative period. Rigid fixation of rib grafts, as with other bone grafts, will decrease the amount of bone resorption.

SURGICAL TECHNIQUE

An inframammary incision is typically used to harvest a rib graft because this provides adequate access and cosmesis as well as access to cartilage and bone. The incision is usually placed between the fourth and fifth intercostal spaces.



FIG. 4-10

(As an alternative, a lateral thoracic incision over the eighth or ninth rib may be used.)

The incision is made through the skin and subcutaneous tissues, and the rib to be harvested is identified. An incision is made through the periosteum of the rib to the bone, and it is then extended medially past the costochondral junction.

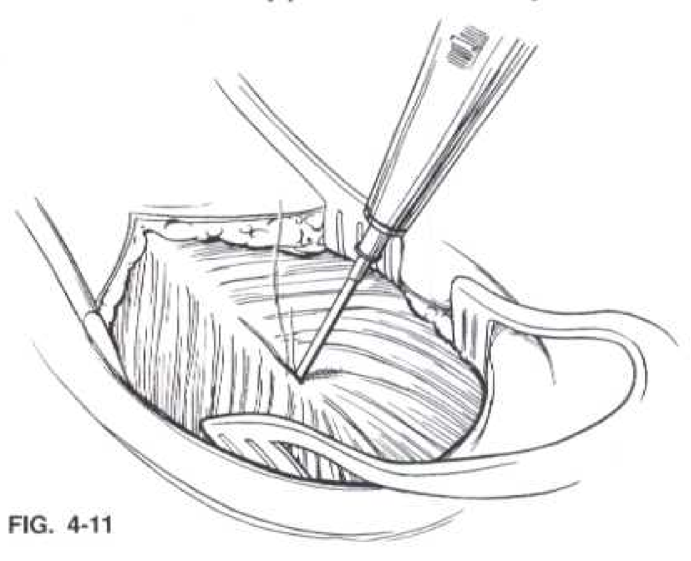


FIG. 4-11

After the incision of the periosteum, an elevator is used to elevate the periosteum from the lateral portion of the rib. This is performed over the entire length of the graft from the costochondral junction to its lateral extent.

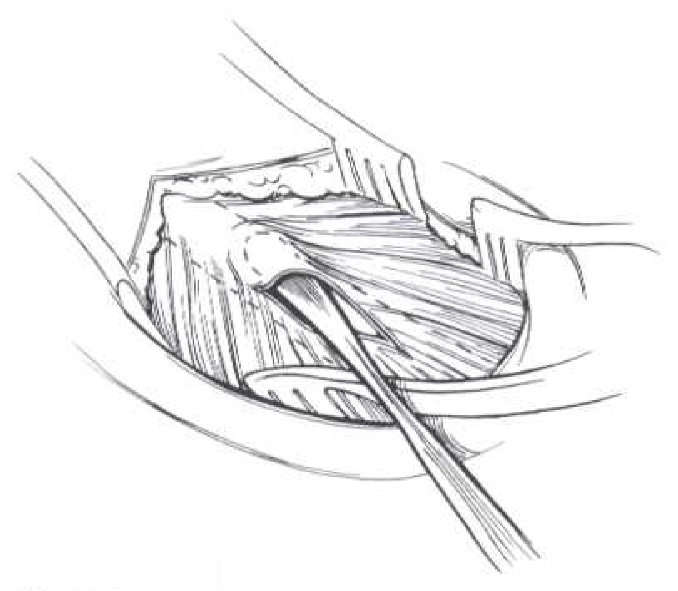


FIG. 4-12

The periosteal elevator is then used to elevate the periosteum from the superior and inferior borders of the rib under direct vision. Particular care should be taken along the inferior border to elevate the intercostal neurovascular bundles from their bed in the rib so that the integrity of the artery and the vein is not violated. Care should also be taken to avoid injury to the intercostal nerve because injury can result in postoperative paresthesia or pain.

Following elevation of the periosteum from the lateral, superior, and inferior surfaces of the rib, circumferential elevation is begun at the costochondral junction.

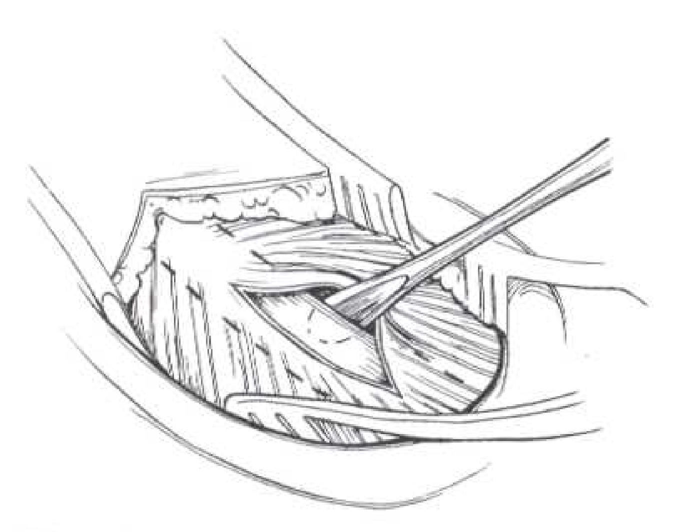


FIG. 4-13

Under direct vision, the periosteal and perichondrial junction is elevated so that a malleable retractor can be placed underneath the rib at this junction. Then a scalpel or heavier instrument is used to section the rib just medial to the costochondral junction. The cartilage is incised through and through to the malleable retractor.

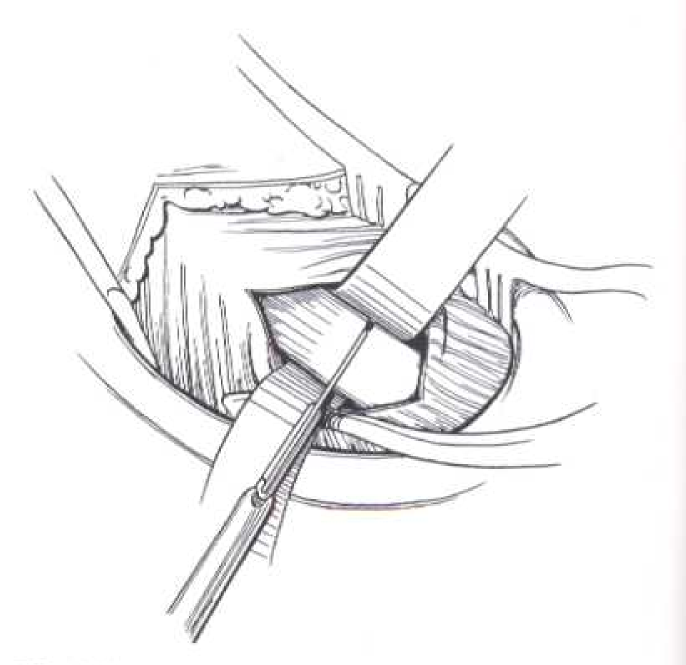


FIG. 4-14

A bone clamp is used to lift the sectioned rib.

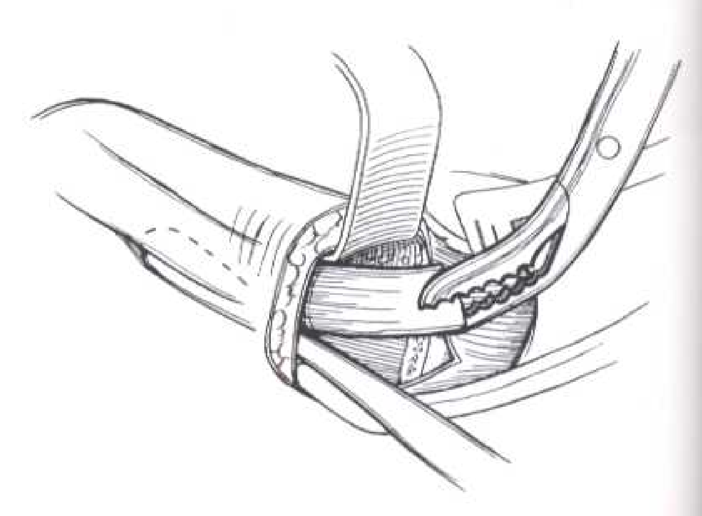


FIG. 4-15

The periosteum of the undersurface of the rib can then be easily dissected free from the bone. This is done for the entire segment of the rib. Blind elevation at this point may lead to tears in the parietal pleura; therefore, direct visualization is recommended.

After the portion of the rib to be harvested has been completely stripped of its periosteum, rib-cutting pliers are inserted into the graft bed, and the rib is sectioned, removed from the donor site, and placed in a saline-wrapped sponge.

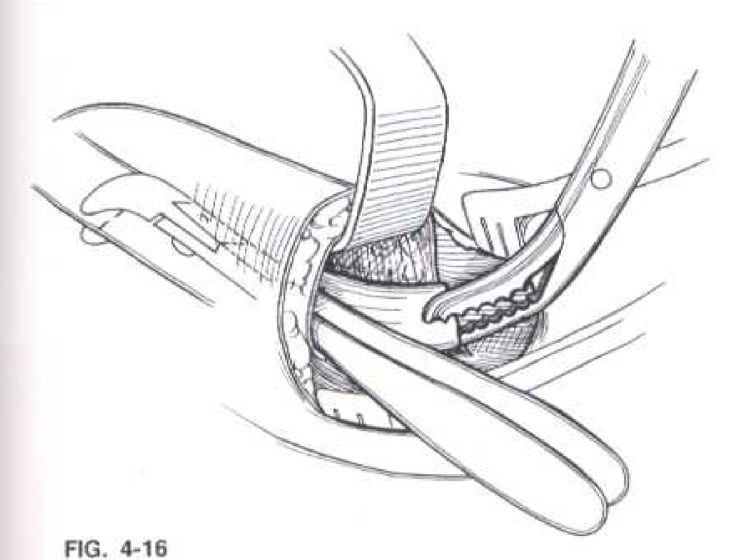


FIG. 4-16

The donor site is now inspected for any pleural lacerations. This can be enhanced by irrigating saline solution into the donor site and having the anesthesiologist inflate the lungs while checking for any bubbling that might occur.

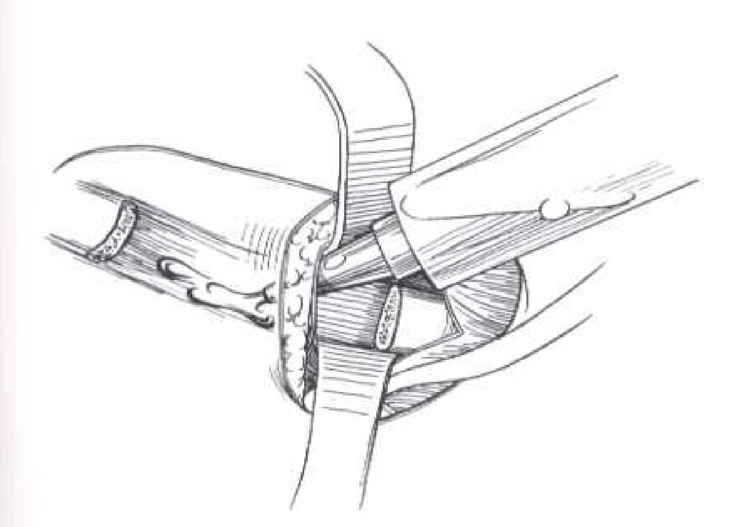


FIG. 4-17

If a pleural laceration is found, it should be repaired at this time. Lacerations involving only the parietal pleura may be repaired while the patient is maintained on positive end-expiratory pressure. If a pleural laceration has extended to the visceral pleura, a chest tube should be placed. Even if no problem has been encountered, a postoperative chest x-ray study should be obtained to rule out the presence of a pneumothorax.

Preparation of the Split Graft

After the rib has been harvested, decortication is then carried out. This can be accomplished by using a hand piece and a flat or pear-shaped cutting burr. The cortex is lightly removed so that the cancellous portion of the rib can be visualized through a thin layer of cortex. The cortex should not be totally removed because this would significantly weaken the graft.



FIG. 4-18

Following decortication of the medial and lateral surfaces, the superior and inferior borders of the rib are completely decorticated to allow for the entry of the osteotome that will be used to split the rib. The osteotome is gently inserted into the midportion of the cancellous cavity between the medial and lateral surfaces. It is rocked back and forth until it passes through and through from superior to inferior.



FIG. 4-19

After the bony portion of the rib has been split, the remaining costochondral junction is split with an osteotome.

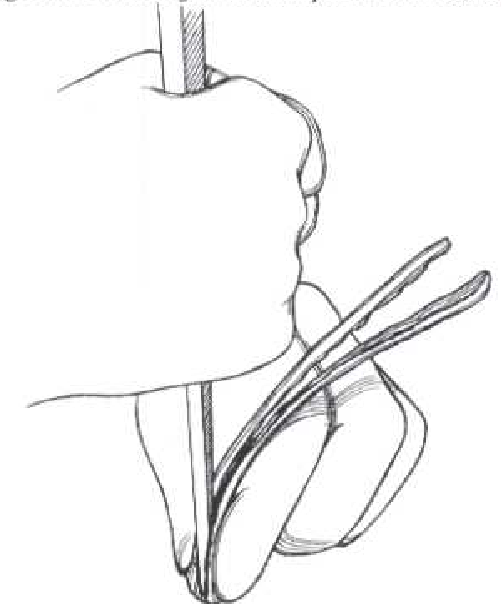


FIG. 4-20

A rib cutter is then used to trim the cartilage from the remaining bone grafts.

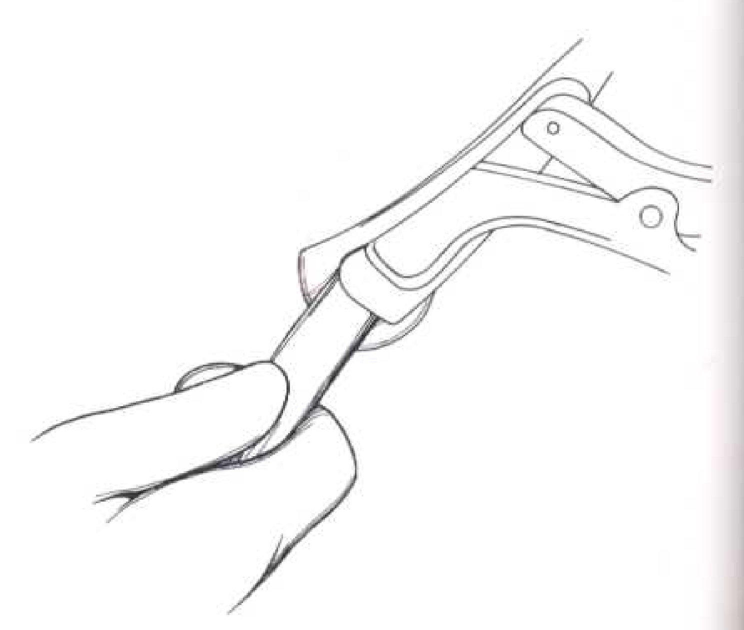


FIG. 4-21

A rib-bending forceps is used to contour the rib into the precise shape that is required for the recipient site.

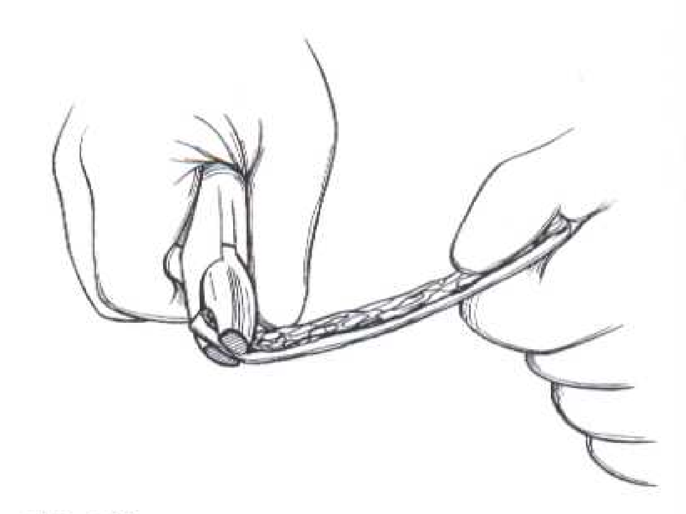


FIG. 4-22

In the following example, a horseshoe-shaped multilayered split rib graft is required for mandibular alveolar ridge augmentation. In this situation, the rib was bent into the desired shape by using five layers of split ribs to achieve the desired thickness.

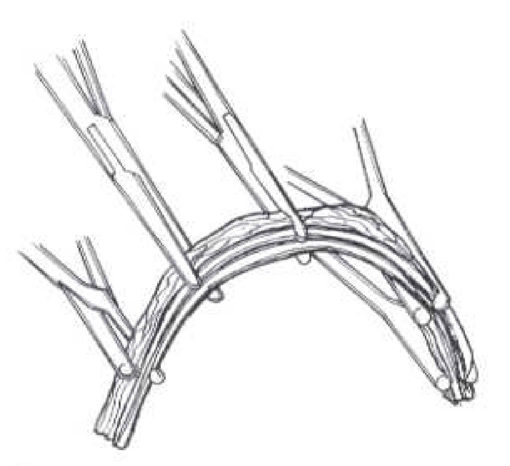


FIG. 4-23

After the desired shape is achieved, Kocher clamps are placed on the graft to maintain this shape. Holes are drilled through the layered rib graft, and wires are passed through these holes. These are tightened to maintain the shape of the graft. Wires are placed between each of the clamps and also between the end of the graft and the first clamp. Following contouring and stabilization with wire fixation, the graft maintains its horseshoe shape.



FIG. 4-24

CHAPTER 3

Iliac Bone Grafts

The ilium has long provided an abundant source of bone graft material for maxillofacial reconstruction. A large amount of bone may be obtained, and the donor graft may be cut to a shape that approximates the recipient site. When used as an onlay material, however, in the upper craniofacial skeleton, it undergoes a significant amount of resorption; therefore, other donor materials such as rib, split rib, or calvarium should be considered.

SURGICAL TECHNIQUE

An incision is made inferior and parallel to the iliac crest.

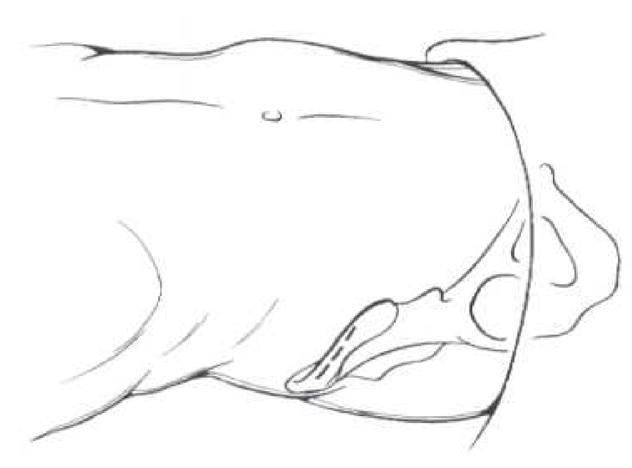


FIG. 4-25

This is carried through the skin and subcutaneous tissue. After it is incised, traction is placed medially on the skin above the ilium to pull the incision directly over the iliac crest. Caution should be taken at this point and throughout the harvest to avoid injury to the lateral femoral cutaneous nerve because meralgia paresthetica may develop following nerve injury, which may be a persistent problem for the patient. The dissection is then continued to the iliac crest.

The graft is outlined by making incisions in the periosteum of the iliac crest. At least 1 cm of intact bone should be maintained posterior to the anterosuperior iliac spine. This provides continued support for the ilioinguinal ligament.

An incision is made through the periosteum at the anterior and posterior margins of the proposed graft. These are connected by a periosteal incision along the medial aspect of the iliac crest. An osteotome is then used to penetrate into the iliac crest along the anterior, posterior, and medial portions of the bone. The cap of iliac crest is then mobilized laterally, leaving it hinged on the periosteum of the lateral aspect of the ilium.

Cancellous Graft

If a particulate cancellous graft is needed, a curette is then used to harvest the bone from the ilium between the medial and lateral cortices.

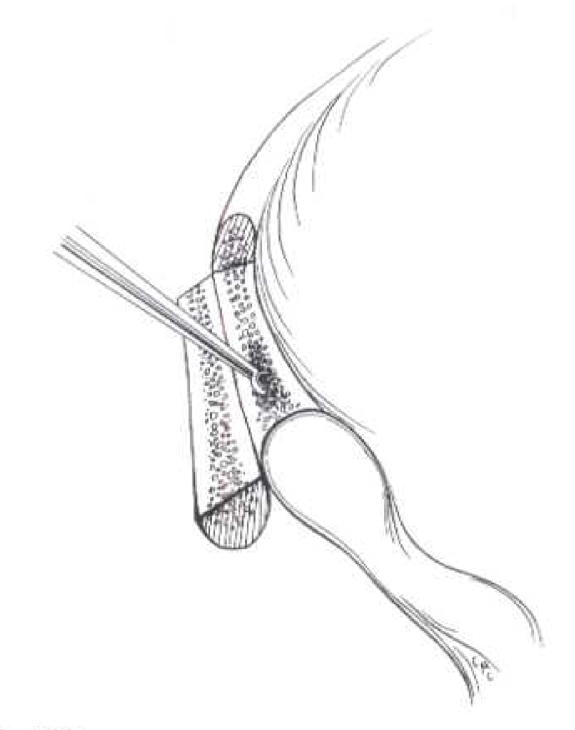


FIG. 4-26

Corticocancellous Graft

If a corticocancellous graft is desired, an osteotome is then driven parallel to and medial to the lateral cortex of the ilium at the corticocancellous junction.

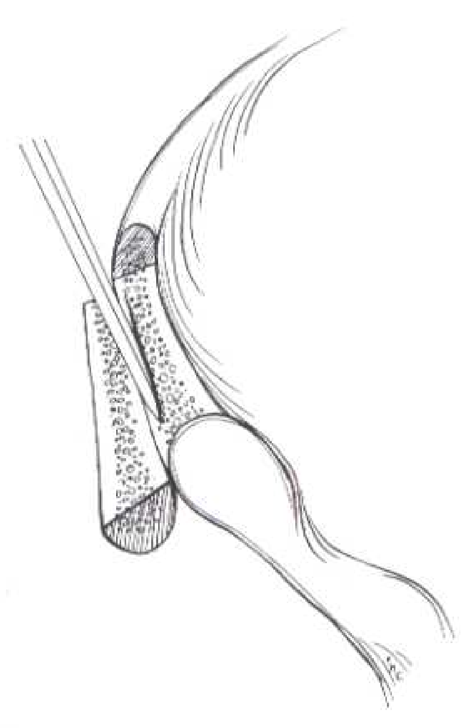


FIG. 4-27

If possible, the lateral cortex of the ilium should remain intact because this decreases trauma to the gluteal muscles and reduces postoperative morbidity. However, if a full-thickness iliac crest graft is required, then the muscles should be detached from the bone prior to bone harvest.

After the medial cortical cancellous portion of the ilium has been dissected free from the lateral cortex, osteotomies are made along the anterior and posterior margins of the bone.

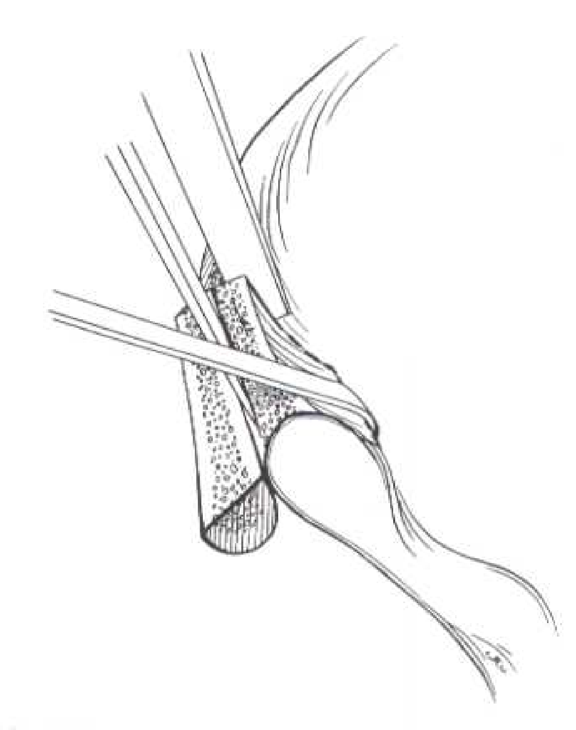


FIG. 4-28

Following this, a curved osteotome is placed inferiorly to complete the osteotomy at the inferior portion of the graft. Care must be taken to avoid inadvertent injury of the peritoneum. The graft is then removed.

Bleeding should be controlled with bone wax or collagen resorbable hemostatic material, depending on the surgeon's preference. A drain is usually placed in the operative site to prevent postoperative hematoma. The iliac crest is then replaced back into position and secured with miniplates, microplates, or periosteal sutures.

Larger plates should be avoided because these will be palpable to the patient, and they may produce discomfort, necessitating their removal. Skin closure is accomplished according to the surgeon's preference.

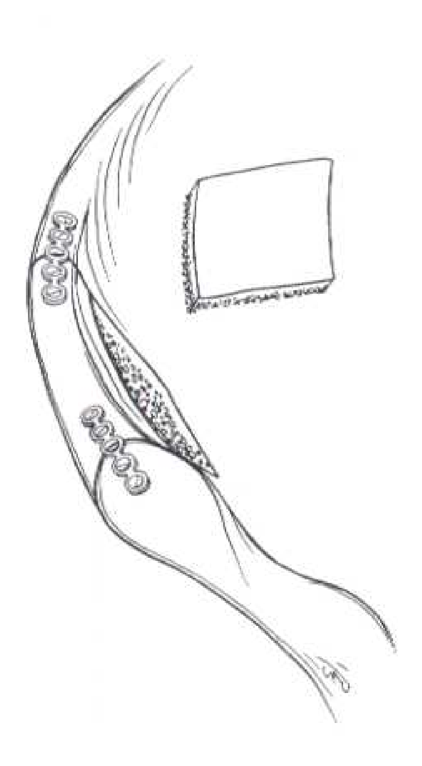


FIG. 4-29

UNIT V

Mandible: Trauma (Fractures)

UNIT OUTLINE

As discussed in Unit 2, the biomechanical forces that work to distract the fractured mandible must be overcome if a dependable outcome is to be consistently achieved. This can be accomplished in many ways. Although it is impossible to depict every possible approach and technique, this section is designed to provide the maxillofacial surgeon with a wide variety of options that properly address the mandibular biomechanics and can therefore be recommended as possible alternatives.

It should be apparent that, as in the rest of this atlas, a wide variety of plating systems are depicted to avoid suggesting that any one system is superior to any other. The reader, however, is cautioned to use only plates and screws that are of appropriate size and strength for the particular circumstance.

NOTE: In this unit, the term "miniplate" is used to refer to a neutral (2.0 mm) mandibular miniplate that is 1 mm thick.

CHAPTER 1

Symphysis: Dentulous (Nonoverlapping)

The fractured mandibular symphysis in the dentulous patient represents in many ways the most straightforward case for rigid fixation. Intermaxillary fixation (IMF) may stabilize the fracture, but despite apparent excellent stabilization, the torsional forces acting on this area can lead to malunion. The use of rigid fixation overcomes these forces and obviates the need for IMF.

Although an external approach may be used, the intraoral incision provides wide access in this area, even allowing for the use of a reduction pliers screwed to the inferior border of the mandible.

TENSION BAND ARCH BAR AND COMPRESSION PLATE

Key Principles	pp. 43, 62
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

The tension band arch bar is first applied to the teeth across the fracture site, and proper occlusion is reestablished. To serve as a tension band, the arch bar must effectively pull the alveolar portion of the fracture together. The fracture is exposed either intraorally or extraorally.

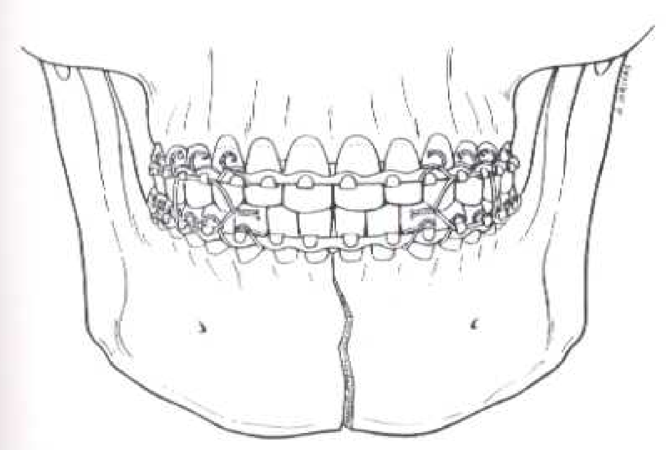


FIG. 5-1

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

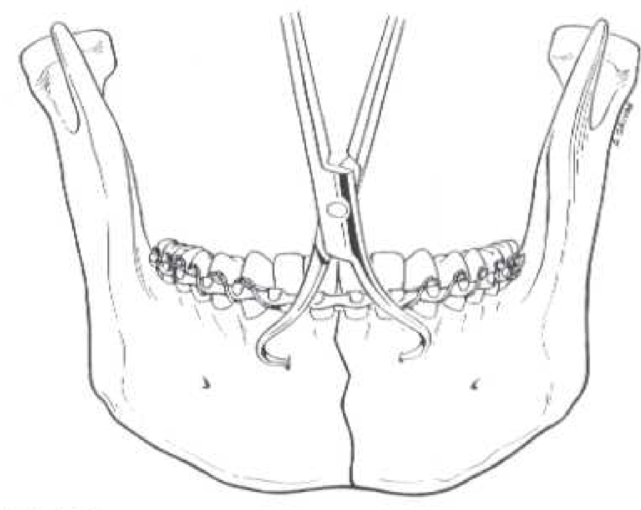


FIG. 5-2

(Optional) A mandibular reduction pliers may be applied along the inferior border of the mandible. Using these pliers, the fragments are reduced, and precompression is applied. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

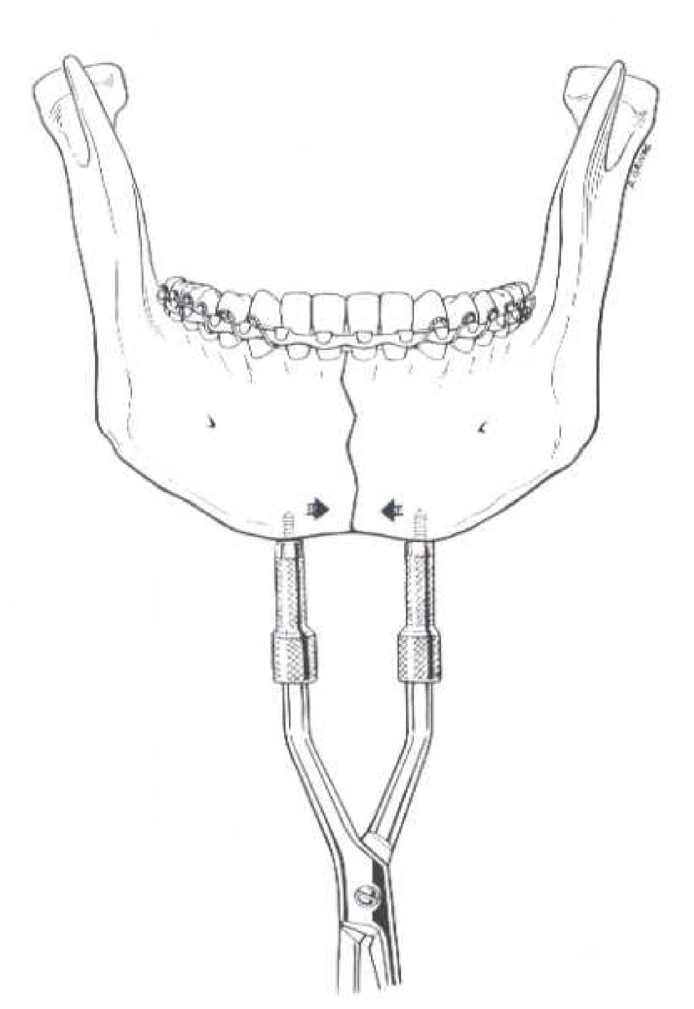


FIG. 5-3

An appropriate compression plate is selected, using at least a four-hole plate. This is fixed along the inferior third of the mandible. Be sure to position the plate below the tooth roots. The plate may be held in place with plate-holding forceps, after precise bending to the mandibular contour has been successfully completed, usually by bending a template first and then bending the plate.

FIG. 5-4

Plate application is completed using two bicortical compression screws eccentrically placed away from the fracture and two to six bicortical neutral screws (obviously depending on the length of the plate).

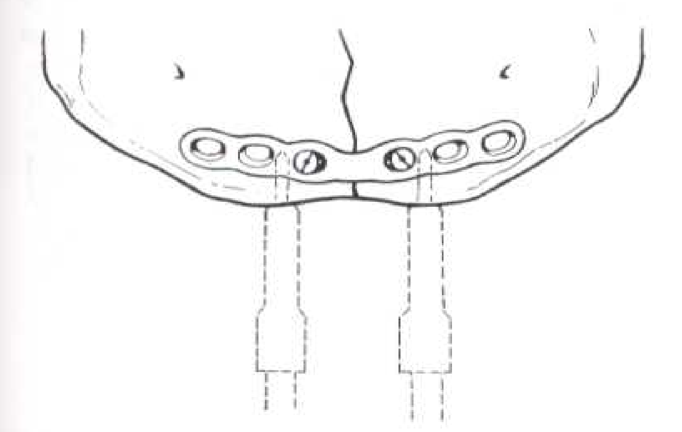


FIG. 5-5

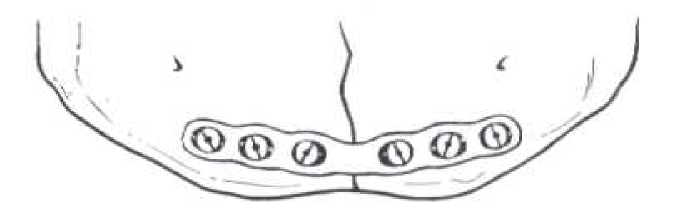


FIG. 5-6

When a mandibular reduction forceps has been used, the locking screw is released after the two compression screws have been placed, and the pliers may be removed completely at any time after four screws have been placed.

The wound is irrigated, drained, and closed. IMF may now be released.

TENSION BAND PLATE AND COMPRESSION PLATE

Key Principles	pp. 42, 43, 61, 62
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

Occlusion is established, but a tension band arch bar has not been placed or is inadequate as a tension band. The fracture is exposed either intraorally or extraorally.

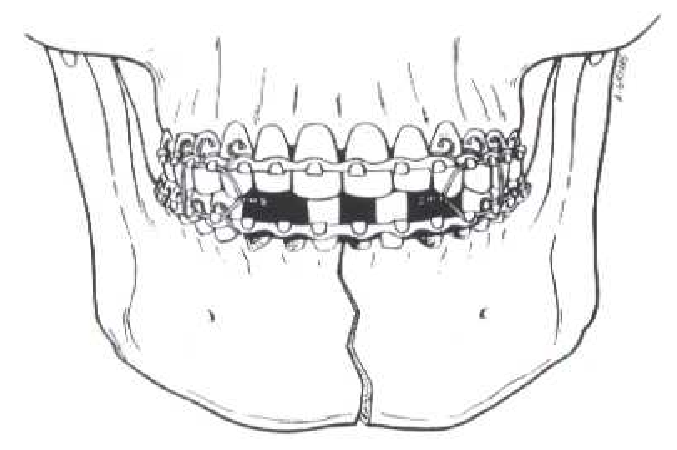


FIG. 5-7

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

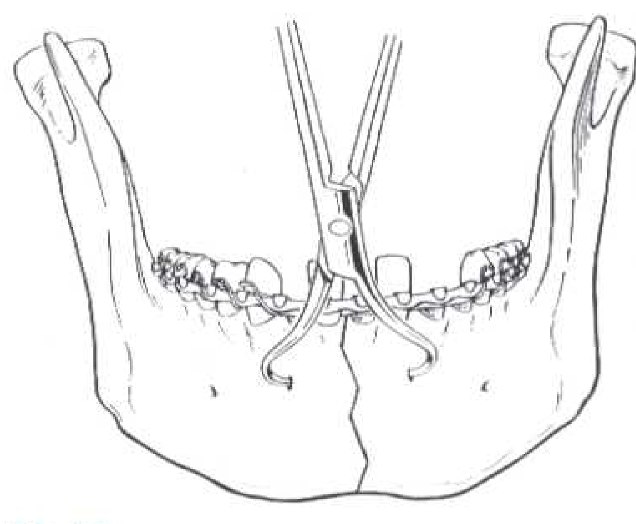


FIG. 5-8

(Optional) A mandibular reduction pliers with side rollers may be fixed to the inferior border of the mandible for reduction and precompression. Rollers must be used because the tension band is inadequate; otherwise, the alveolar portion of the fracture will be distracted. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

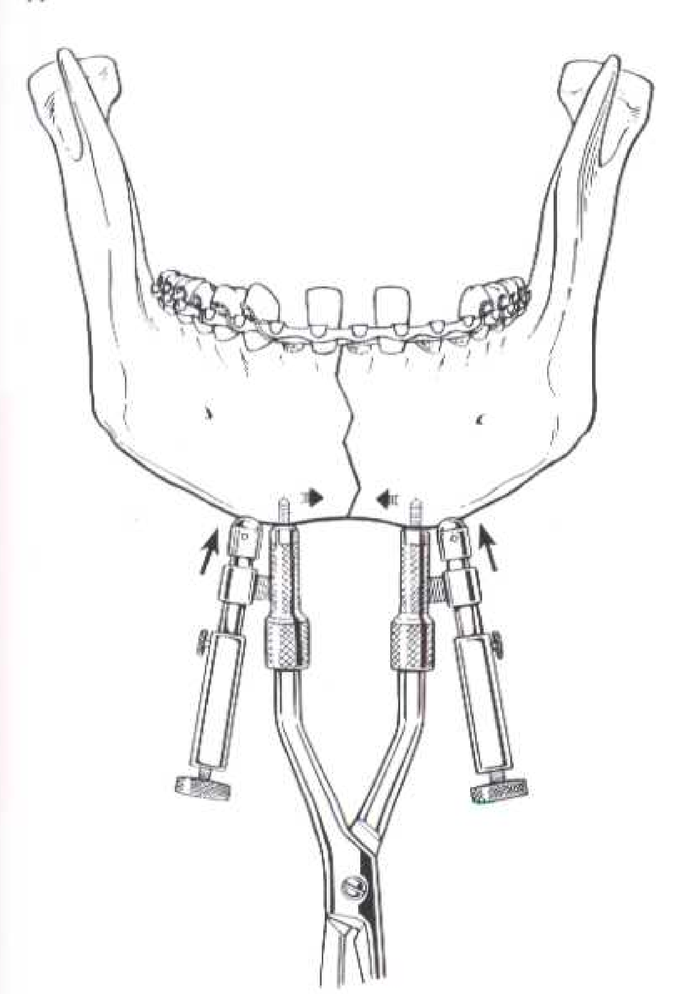


FIG. 5-9

A tension band miniplate is applied along the tension line of Champy, using at least a four-hole plate; this is between the mental nerves and below the tooth roots. Monocortical or bicortical screws may be used in the symphyseal region because the inferior alveolar nerves are not at risk.

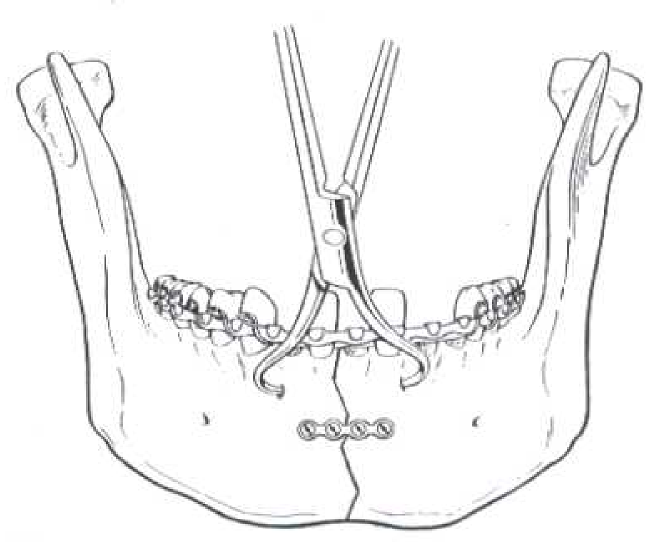


FIG. 5-10

As an alternative, a two-hole compression plate may be used as a tension band plate in the symphyseal area because the inferior alveolar nerves are not at risk. This plate is carefully bent to the mandibular contour. Bicortical screws are placed eccentrically in the plate holes (away from the fracture) so that the fracture is compressed.

An appropriate compression plate is selected, using at least a four-hole plate. This is fixed along the inferior portion of the mandible. The plate is held in position with plate-holding forceps, after precise bending to the mandibular contour has been successfully completed, usually bending a template first, and then bending the plate.

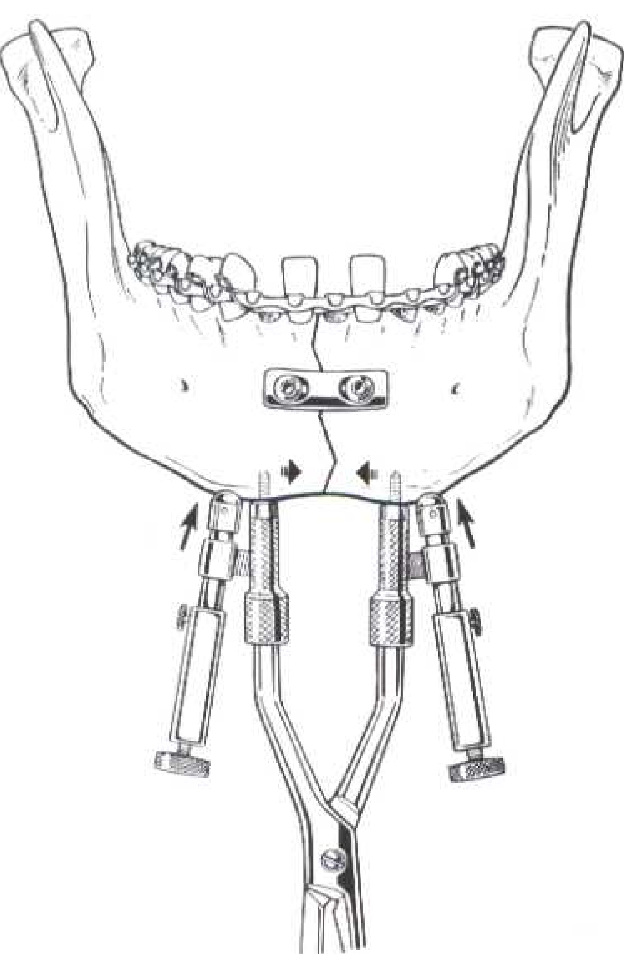


FIG. 5-11

FIG. 5-12

Plate application is completed by using two bicortical compression screws eccentrically placed away from the fracture and

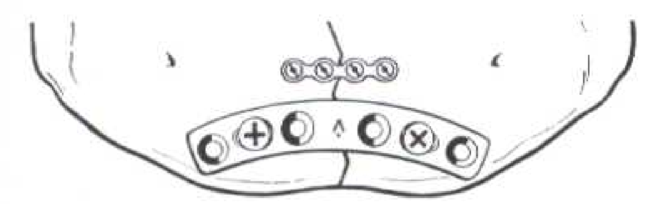


FIG. 5-13

two to six bicortical neutral screws (obviously depending on the length of the plate).

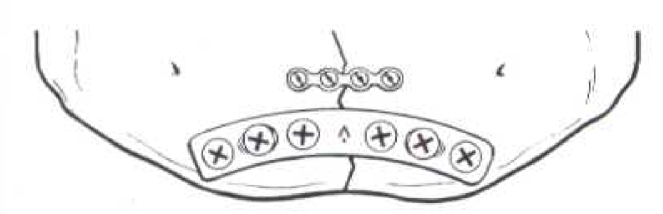


FIG. 5-14

Because a tension band plate has been applied, the technique for application of the inferior compression plate is the same whether the tension band plate is a miniplate or a two-hole compression plate.

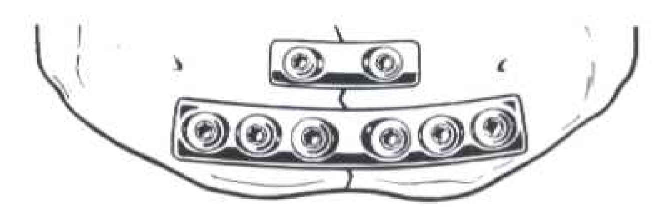


FIG. 5-15

When a mandibular reduction forceps is used, the locking screw is released after the two compression screws have been placed, and the pliers may be removed completely at any time after four screws have been placed.

The wound is irrigated, drained, and closed. IMF may now be released.

MINIPLATE FIXATION

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 71

Occlusion is established using loops or arch bars for IMF. For miniplate fixation, an intraoral exposure is generally used.

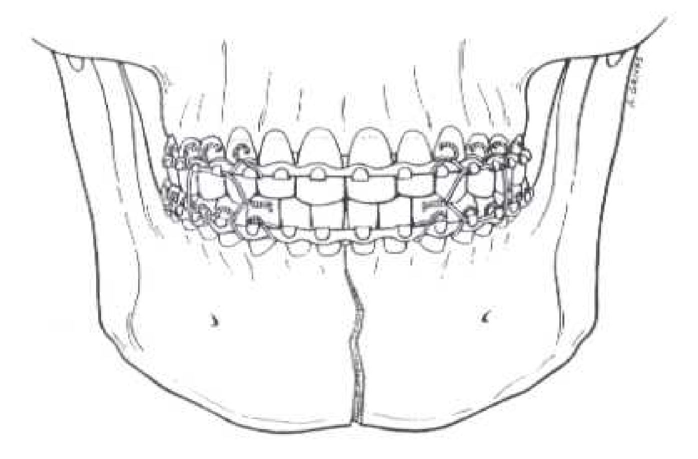


FIG. 5-16

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

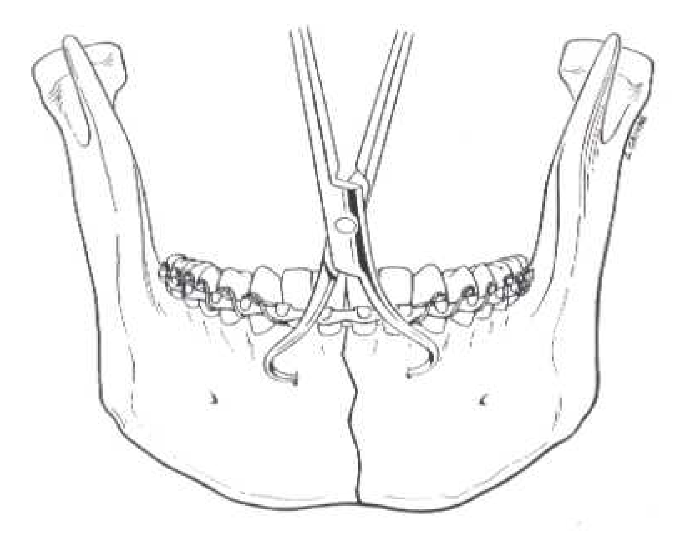


FIG. 5-17

Two miniplates are necessary for stable fixation at the symphysis. The first miniplate is placed by using monocortical screws (although, in this area, bicortical screws are safe) placed sequentially, one at a time, along the tension line of Champy. This is below the tooth roots, generally at least 1.5 to 2 crown heights below the gingival margin. In the symphyseal region, the inferior alveolar nerves are not at risk.

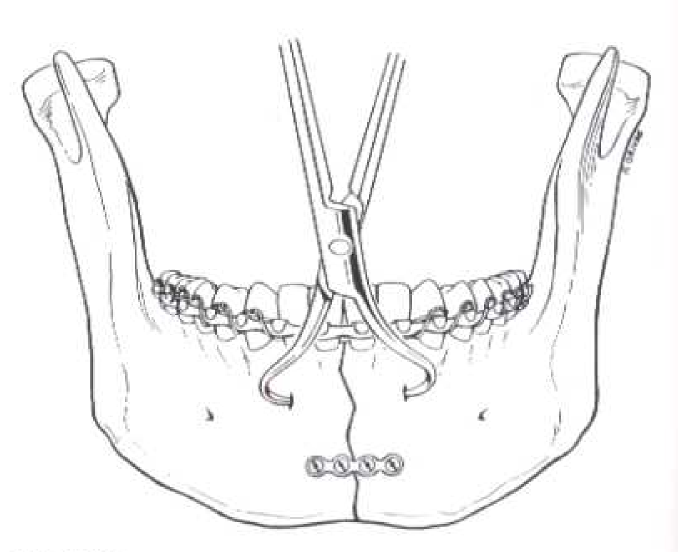


FIG. 5-18

The second miniplate is applied by using monocortical screws (although inferiorly, bicortical screws may be used safely) along the inferior ideal osteosynthesis line. This is above the inferior border. In the symphyseal region, two miniplates are necessary to overcome the torsional forces acting on this area.

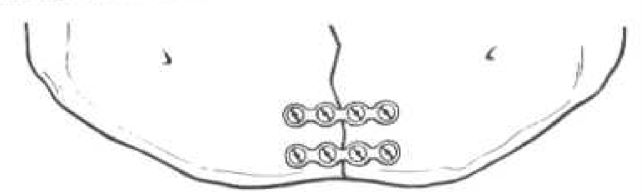


FIG. 5-19

The towel clip is removed, and the wound is irrigated, drained, and closed. IMF may now be released.

THREE-DIMENSIONAL PLATE FIXATION

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 71

NOTE: *It is imperative, when using the three-dimensional plate for mandible fracture repair that plates of the proper thickness and size be used. The 1.0-mm thick plate is used with 2.0-mm screws. A three-dimensional microplate should not be used for mandibular repair.*

Occlusion is established using loops or arch bars for IMF. For three-dimensional plate fixation, an intraoral exposure is generally used.

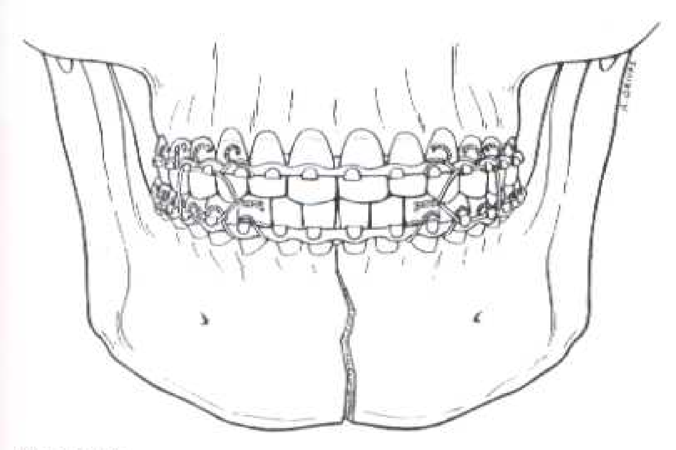


FIG. 5-20

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

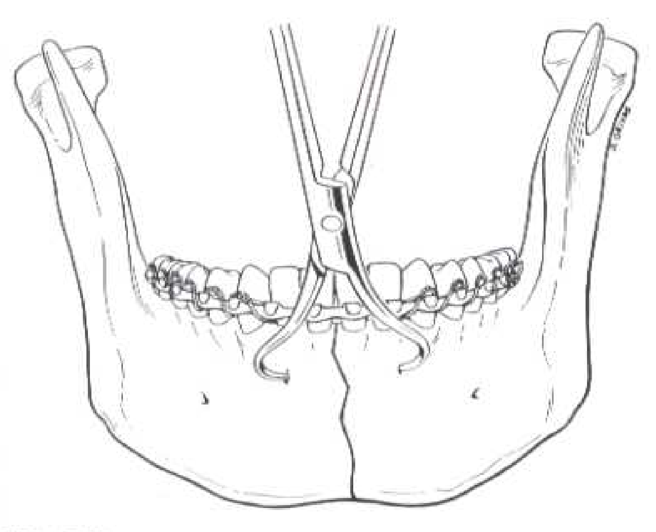


FIG. 5-21

A 2 x 2 (square four-hole) three-dimensional plate is positioned so that the horizontal crossbars are perpendicular to the fracture and the vertical crossbars are parallel to the fracture. Monocortical screws are placed in the two superior holes, making certain that the most superior screw is at least 5 mm below the tooth roots, generally at least 1.5 to 2 crown heights below the gingival margin.

The two inferior screws are now placed. These may be either monocortical or bicortical because the inferior alveolar nerves are not at risk in the symphyseal region.

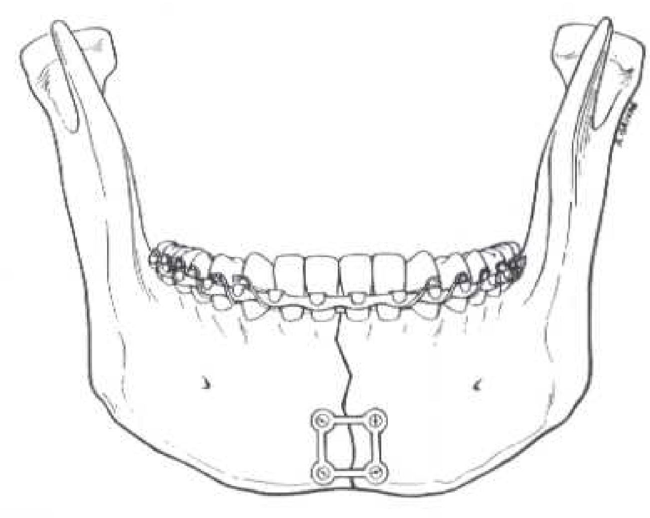


FIG. 5-22

The towel clip is removed, and the wound is irrigated, drained, and closed. IMF may now be released.

ECCENTRIC DYNAMIC COMPRESSION PLATE (EDCP)

Key Principles	pp. 44, 66
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

NOTE: *This is not the preferred or recommended technique by the authors for this situation. The authors believe that, when it is possible, a tension band technique is preferred if a compression plate is to be used.*

Occlusion is established, but a tension band arch bar has not been placed or is inadequate. The fracture is generally exposed extraorally.

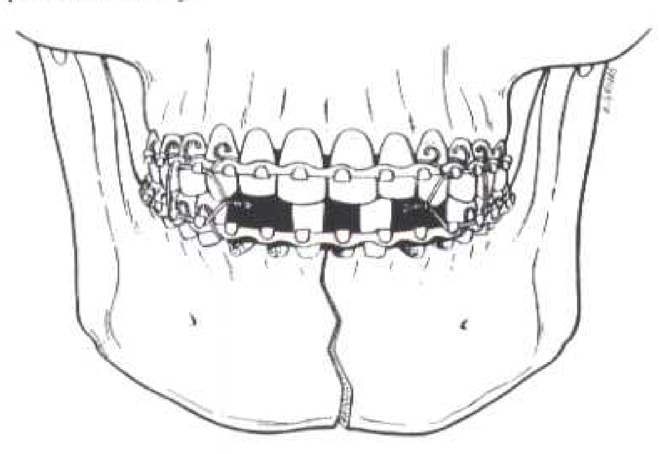


FIG. 5-23

When using an EDCP, the alveolar border (traction side) of the mandible must be precompressed. A modified towel clip may be used, although the mandibular reduction pliers with side rollers for superior precompression is recommended. This is fixed to the inferior border of the mandible. Horizontal precompression is first applied, followed by vertical precompression with the rollers. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

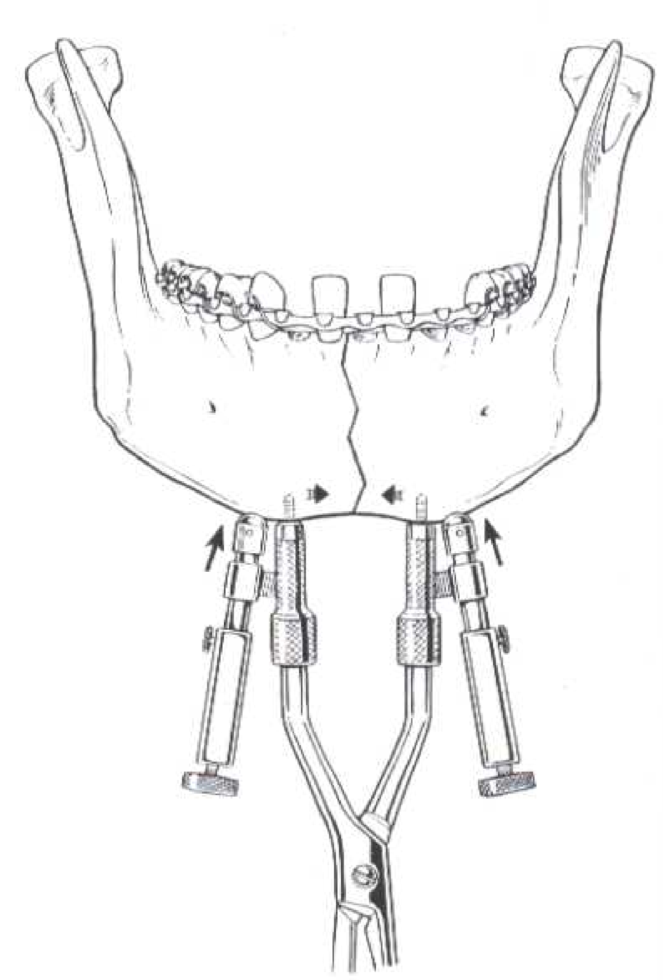


FIG. 5-24

An appropriate EDCP is selected. Because the EDCP has a top and a bottom, care must be used to make certain that this plate is not applied upside down. **The diagonal holes should point superiorly toward the fracture line!** A template is usually bent to shape first, and the plate is carefully bent to match the template and then, ultimately, the bone. After precise bending to match the mandibular contour has been completed, the plate is positioned and held in place with a plate-holding forceps.

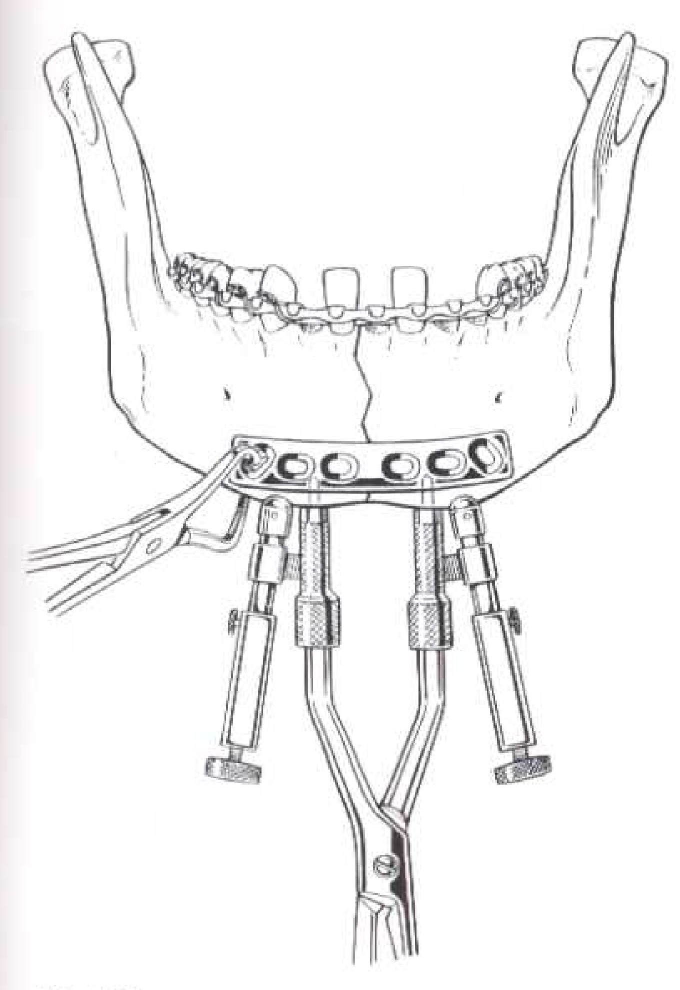


FIG. 5-25

First, two horizontal compression screws are placed bicortically, positioning them eccentrically away from the fracture to produce horizontal compression. The locking screw on the reduction pliers is released.

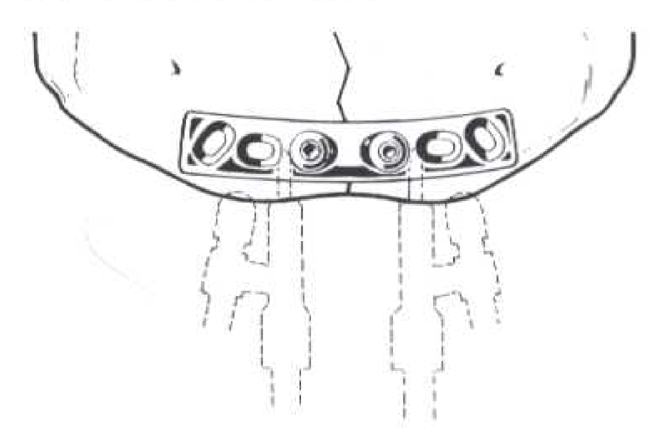


FIG. 5-26

The two superiorly directed compression screws are then placed bicortically, but only after the horizontal compression screws have been fully tightened. These are positioned inferiorly so that compression is directed toward the alveolar border of the fracture. The reduction pliers are then removed.

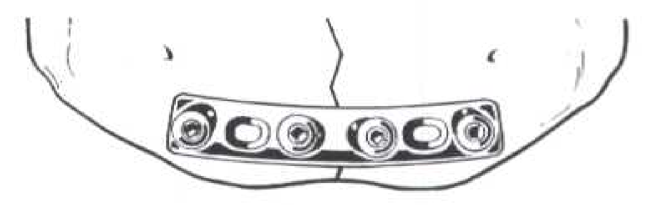


FIG. 5-27

Additional screws (when more than a four-hole plate has been used) are placed neutrally.

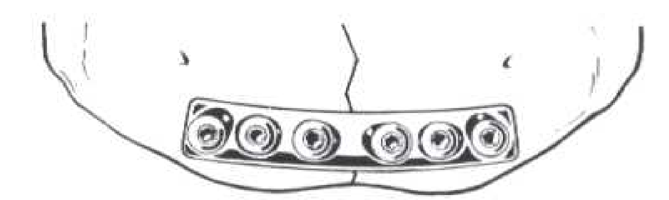


FIG. 5-28

The wound is irrigated, drained, and closed. IMF may now be released.

MANDIBULAR RECONSTRUCTION PLATE

Key Principles	pp. 46, 68 (61, 62)
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

NOTE: *Although the mandibular reconstruction plate provides adequate stability in the absence of a tension band, a tension band is still helpful in making certain that the reduction is properly maintained during repair. The authors therefore recommend that a tension band arch bar be placed when possible. When this is not possible, or is inadequate, a tension band miniplate may be applied if desired.*

Occlusion is first established by using a tension band arch bar or loops. The fracture is exposed either intraorally or extraorally.

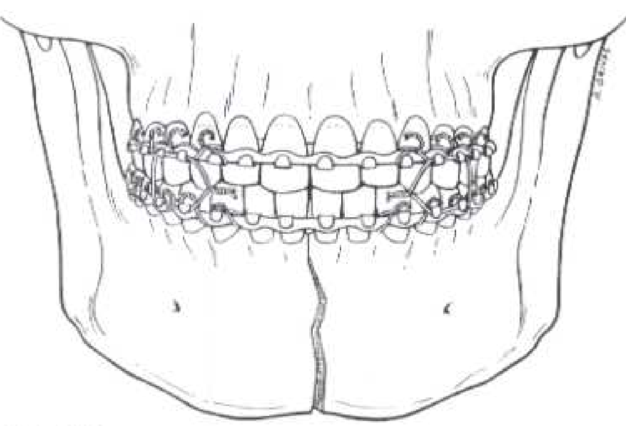


FIG. 5-29

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

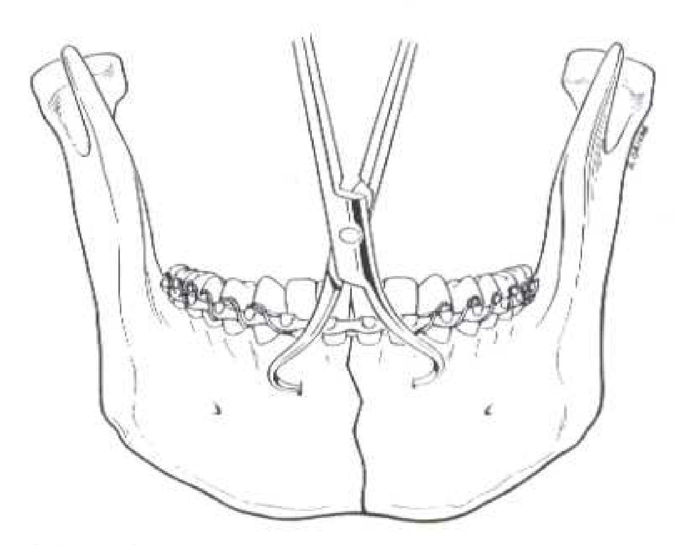


FIG. 5-30

(Optional) A mandibular reduction pliers may be applied along the inferior border of the mandible. No rollers are necessary, if a tension band arch bar has been applied.

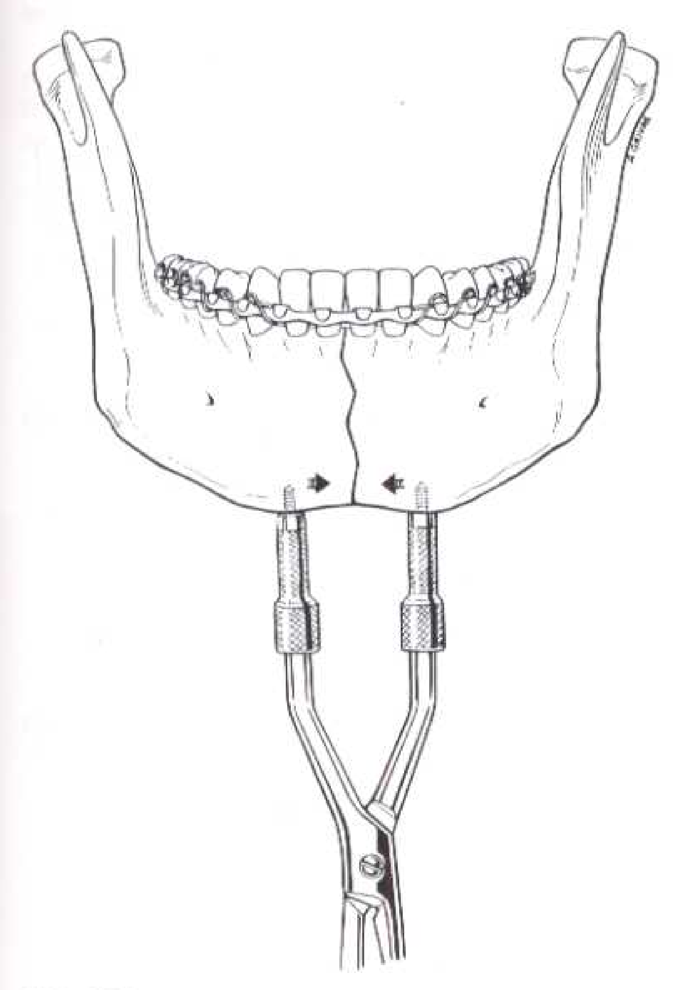


FIG. 5-31

If no tension band has been applied, then superior compression using the side rollers is mandatory if the compression pliers are used. Otherwise, compression of the inferior border will result in separation at the alveolar border. Using these reduction pliers, horizontal precompression can be applied. Tightening the rollers provides superiorly directed forces to compress the alveolar border when no tension band is present. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

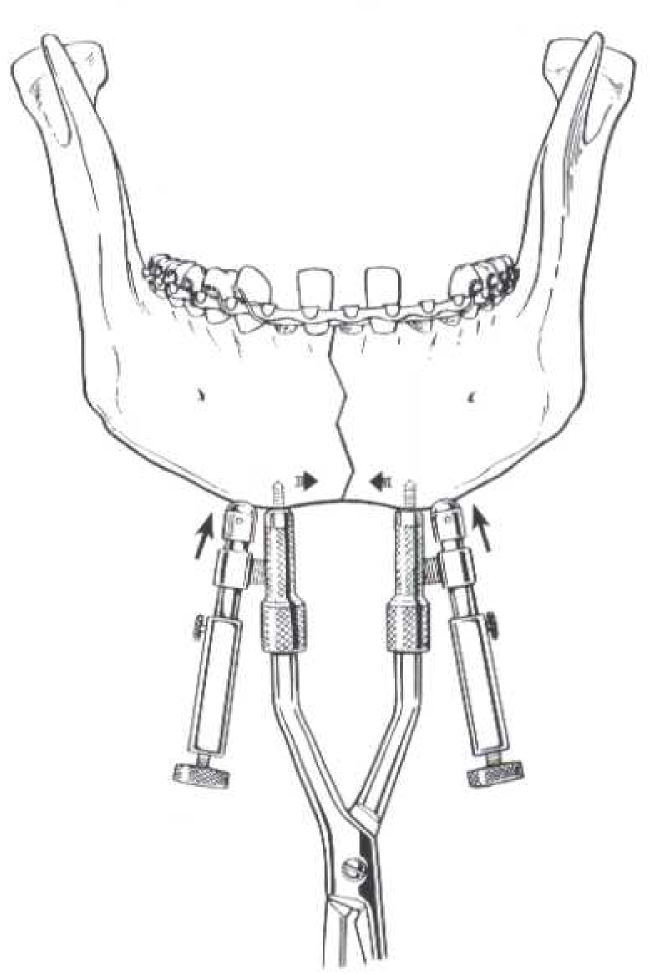


FIG. 5-32

(Optional) If no arch bar has been applied, a four-hole miniplate or a two-hole compression plate may be applied as a tension band. (If a miniplate is applied as a tension band, this is applied along the tension line of Champy by using at least a four-hole plate; this is between the mental nerves and below the tooth roots. Monocortical or bicortical screws may be used in the symphyseal region because the inferior alveolar nerves are not at risk.

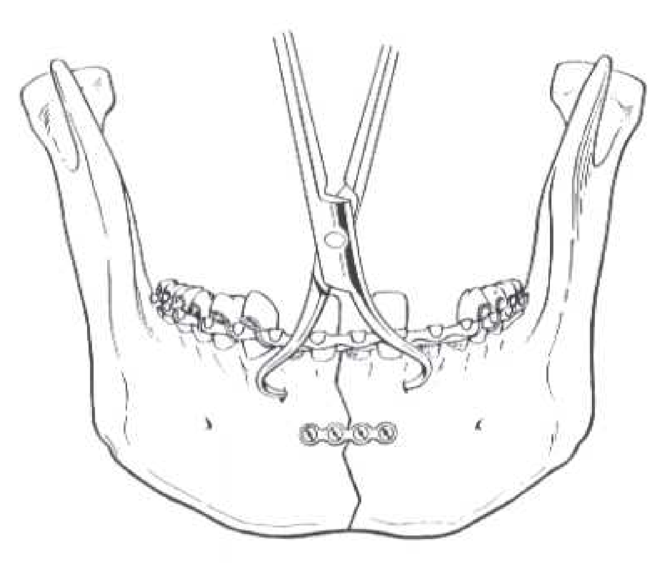


FIG. 5-33

If a two-hole compression plate is used as a tension band (this can be done in the symphyseal area because the inferior alveolar nerves are not at risk), then this plate is carefully bent to the mandibular contour and applied by using bicortical screws. These are placed eccentrically in the plate holes (away from the fracture) so that the fracture is compressed.

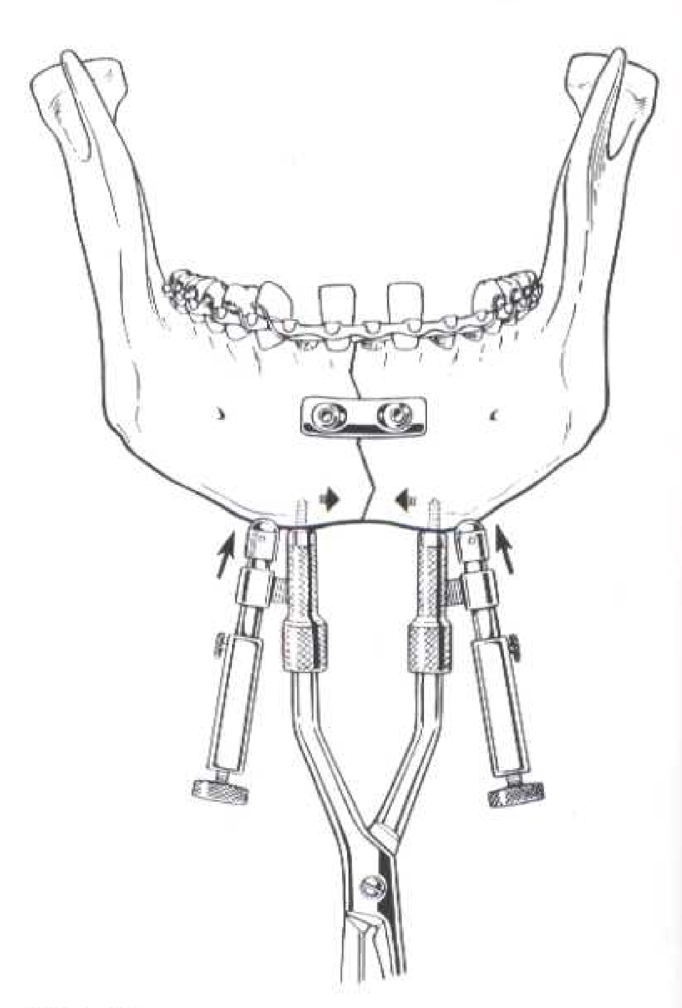


FIG. 5-34

A mandibular reconstruction plate with at least six holes is selected. A template is bent to match the mandibular contour, and the plate is carefully bent to match the template and ultimately the mandibular contour of the inferior mandibular border.

Bicortical screws are used. If a tension band has been placed, the first two screws can be placed eccentrically away from the site of the fracture to produce compression. The remaining screws are then placed neutrally.

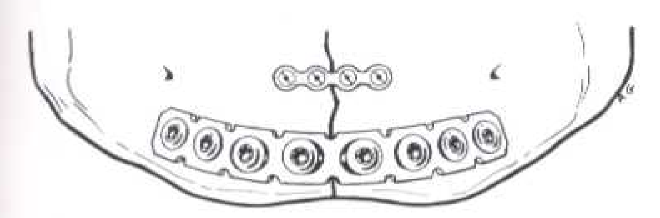


FIG. 5-35

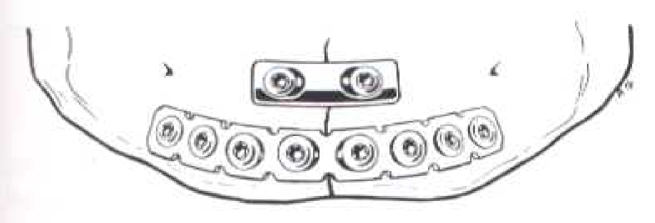


FIG. 5-36

When there is no tension band present, all screws are placed neutrally, placing at least three screws on each side of the fracture, although four or five on each side provide greater stability.

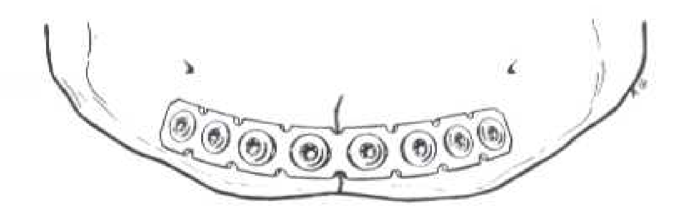


FIG. 5-37

The wound is irrigated, drained, and closed. IMF may now be released.

LAG SCREW FIXATION

Key Principles	pp. 47, 50
Surgical Approaches	
Intraoral	p. 71

NOTE: *When using this technique, long screws (38–44 mm) must be available.*

Occlusion is first established by using arch bars or loops. A tension band arch bar is preferred. The fracture is exposed intraorally.

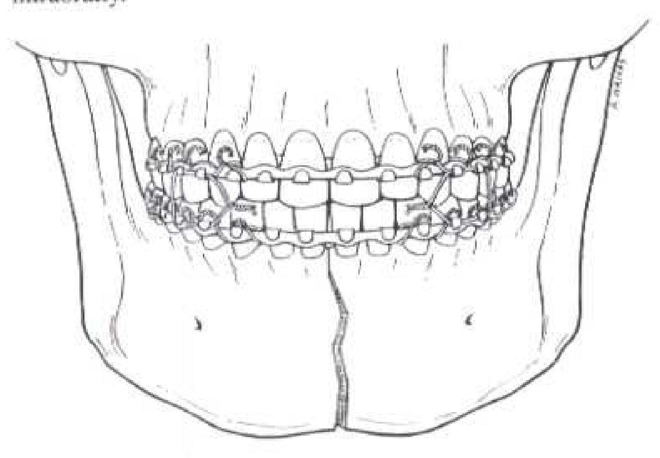


FIG. 5-38

A small notch is drilled on either side of the fracture so that the prongs of a modified towel clip can grasp the bone. The towel clip is applied across the fracture for reduction and precompression.

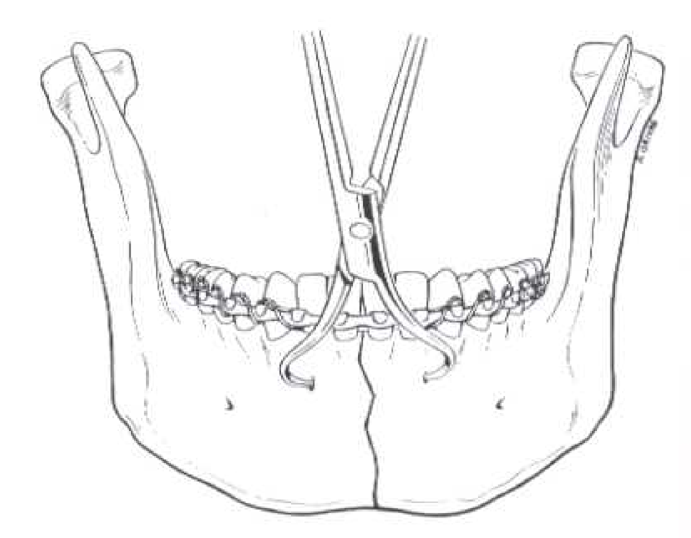


FIG. 5-39

Using a drill guide, a gliding hole (generally, 2.7 mm) is drilled from lateral to medial through one fragment, near the midportion.

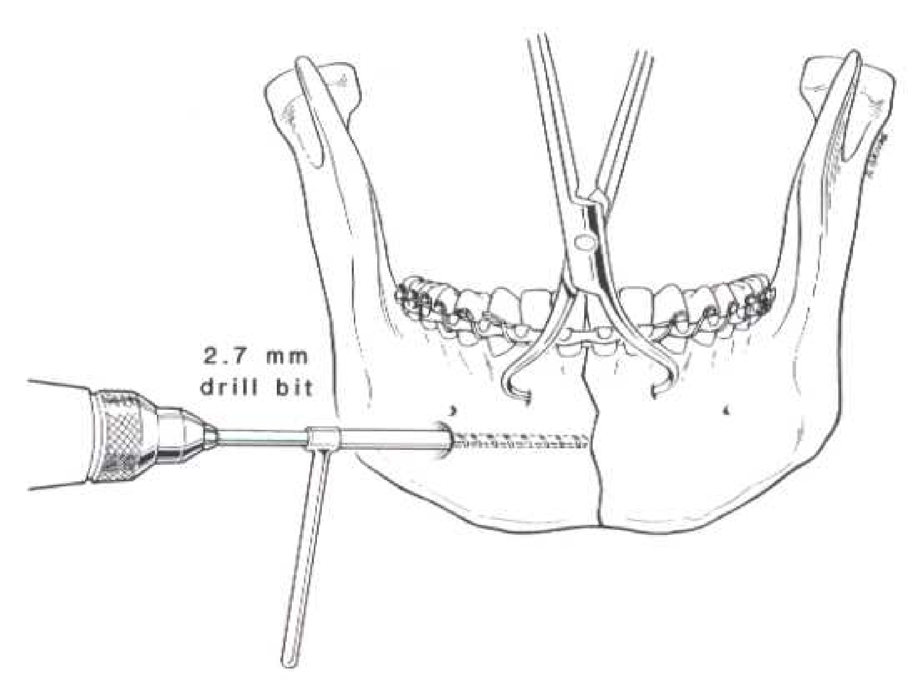


FIG. 5-40

A drill guide can now be placed into the gliding hole, and the second fragment is drilled (generally, 2.0 mm). A countersink is used to enlarge the first hole for proper seating of the screw head.

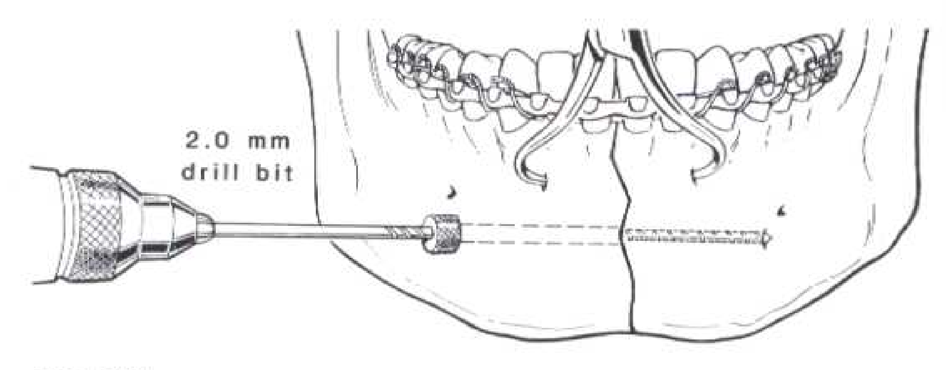


FIG. 5-41

The hole is measured with a depth gauge, taking care to catch the full depth through the second fragment. (When using a non self-tapping system, the distal hole is tapped.)

An appropriate length screw is placed and tightened.

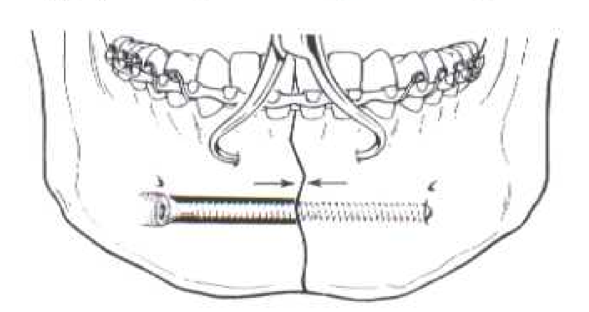


FIG. 5-42

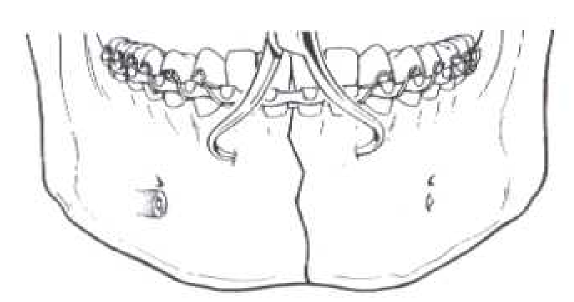


FIG. 5-43

A second lag screw may be placed inferiorly by repeating the same process.

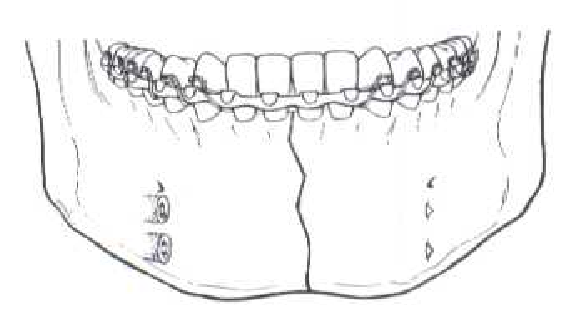


FIG. 5-44

The towel clip is removed, and the wound is irrigated, drained, and closed. IMF may now be released.

CHAPTER 2

Symphysis: Edentulous (Nonoverlapping)

The absence of teeth does not negate the importance of establishing the proper relationship of the mandible and maxilla for function. If the patient has dentures, it is preferable to use these as the best guide to the patient's functional occlusion and, therefore, the proper position of the bone fragments. These can be modified to include arch bars to allow for the easy creation of the proper occlusal relationship. If the patient does not have dentures, it is recommended that the occlusal relationship be established with splints.

If the bone is very atrophic, we recommend the use of a mandibular reconstruction plate or a bone grafting technique to increase the likelihood of achieving stability and, therefore, bony union.

COMPRESSION PLATE WITH OR WITHOUT A TENSION BAND (MINIPLATE OR COMPRESSION PLATE)

Key Principles	pp. 42, 43, 61, 62
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

The occlusal relationship is first established using dentures or splints. The fracture is exposed either intraorally or extraorally.

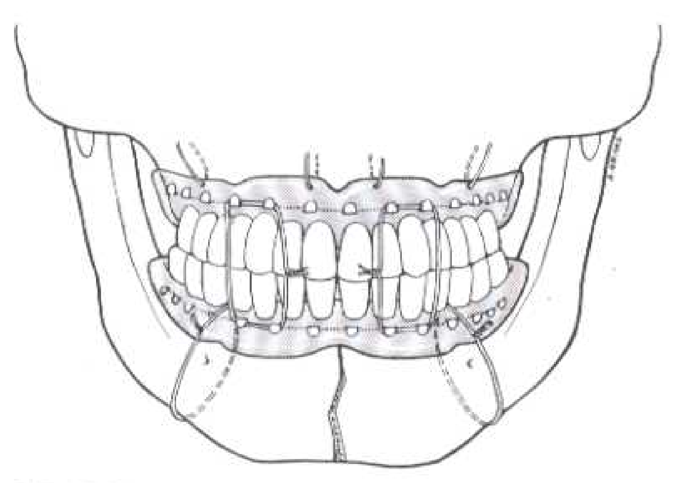


FIG. 5-45

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for the purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

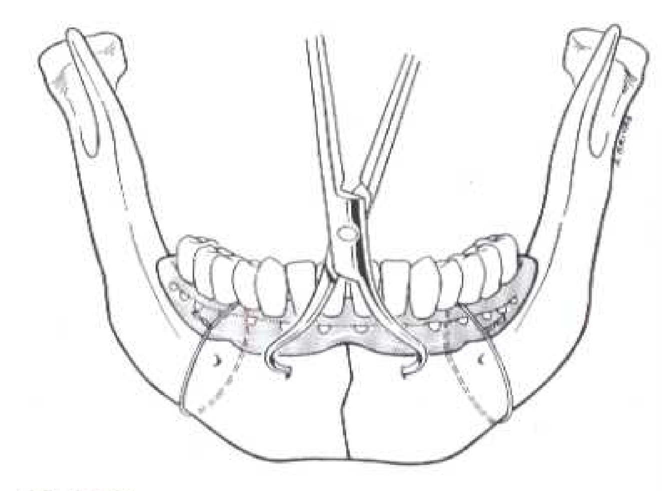


FIG. 5-46

(Optional) A mandibular reduction pliers with side rollers for superior compression may be applied along the inferior border. This is fixed to the inferior mandible with screws, using care to place these screws between the anticipated plate holes so that they do not interfere with plate application. Horizontal precompression is first applied, and then the lock screw is tightened. The rollers are then used to compress the superior borders of the fragments together.

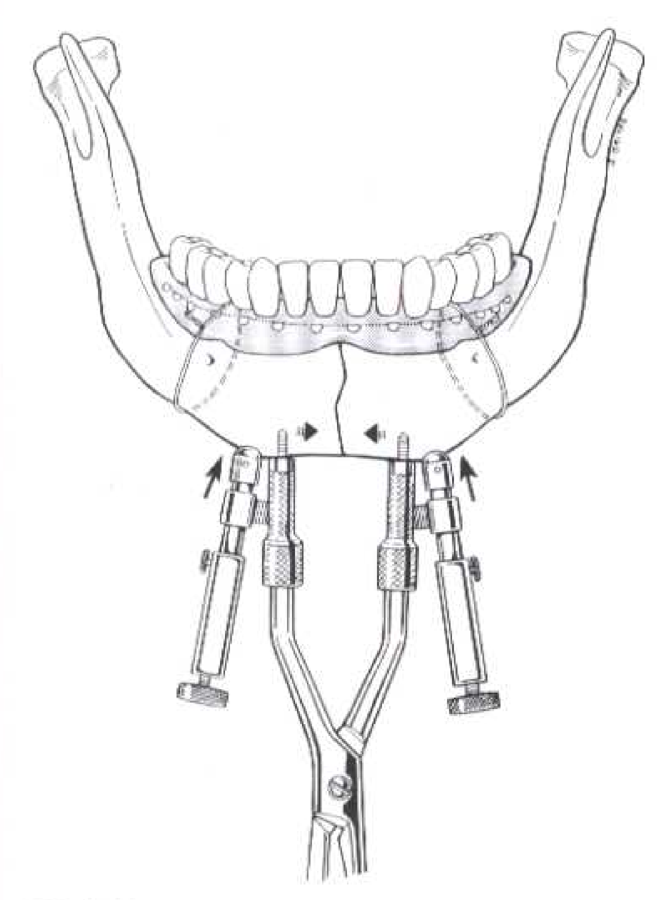


FIG. 5-47

In the absence of teeth, a compression plate may be placed in a central biomechanically stable position because the nerve is not present anteriorly. In this situation, a tension band plate is not applied. A minimum of six holes is recommended.

The plate is bent and applied. A template is usually shaped to the bony contour first, and the plate is then carefully bent to match the template and then, ultimately, the bone. After precise bending to match the mandibular contour has been completed, the plate is positioned and held in place with a plate-holding forceps.

The first two screws are placed eccentrically away from the fracture for compression, making sure to use bicortical screws.

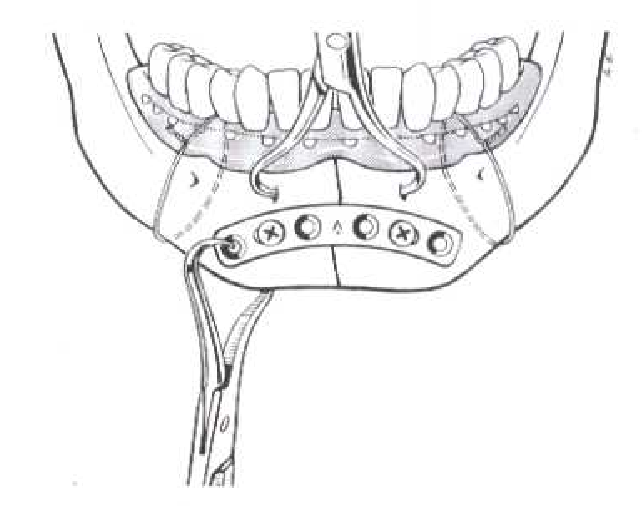


FIG. 5-48

The remaining screws are positioned neutrally in the plate holes. These are also placed bicortically.

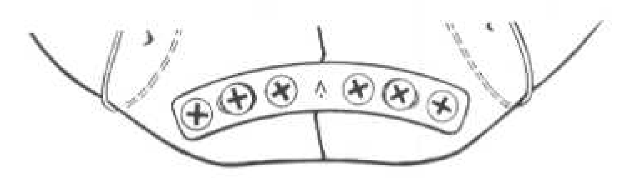


FIG. 5-49

If a reduction forceps has been used, the lock screw is released after the compression screws are placed, and the pliers are removed once four screws have been placed.

(Optional) Instead of placing the compression plate centrally on the bone, a tension band plate may be placed superiorly, followed by a compression plate inferiorly. This adds to the stability of the repair and adds to the resistance to torsional movements.

(Option 1) A two-hole compression plate may be used as a tension band. This is bent to the shape of a template and then the bone on the upper half of the mandible. Two bicortical screws are placed eccentrically away from the fracture so that compression is produced. A compression plate is then bent and fixed to the lower mandible, using at least a four-hole plate. Two bicortical screws are placed eccentrically for horizontal compression, and the remaining screws (also bicortical) are placed neutrally.

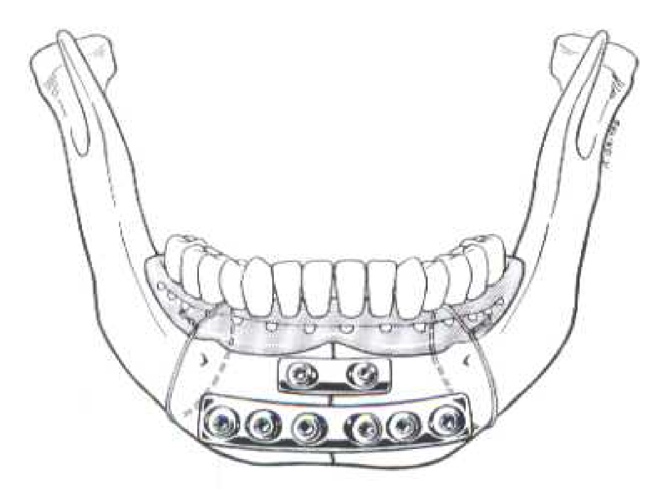


FIG. 5-50

(Option 2) A miniplate may be used as a tension band, using at least a four-hole plate. This is applied along the upper half of the mandible across the fracture. It is carefully bent to shape and applied by using either monocortical or bicortical screws because there are no teeth and the inferior alveolar nerves are not at risk. A compression plate is then bent and fixed to the lower mandible, using at least a four-hole plate. Two bicortical screws are placed eccentrically for horizontal compression, and the remaining screws (also bicortical) are placed neutrally.

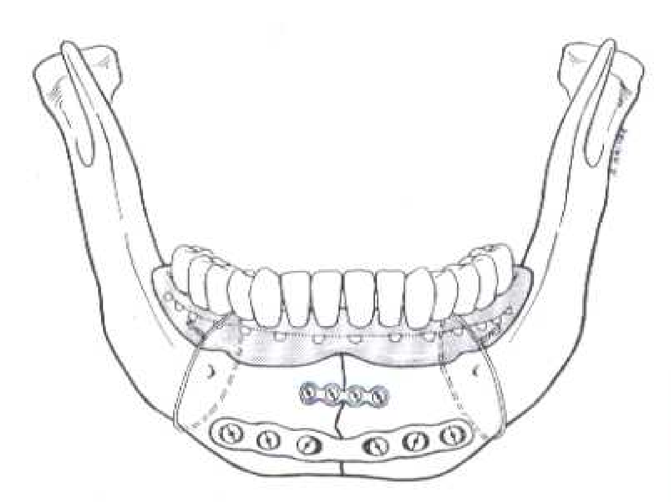


FIG. 5-51

The mandibular fixation device (towel clip or reduction pliers) is removed, and the wound is irrigated, drained, and closed. IMF may now be removed.

MINIPLATE FIXATION

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 71

Occlusion is established using dentures or splints. (Some experienced surgeons perform miniplate fixation in this situation without using splints; however, establishing the occlusal relationship provides a more dependable outcome, particularly when the patient has more than one fracture site.) For miniplate fixation, an intraoral exposure is generally used.

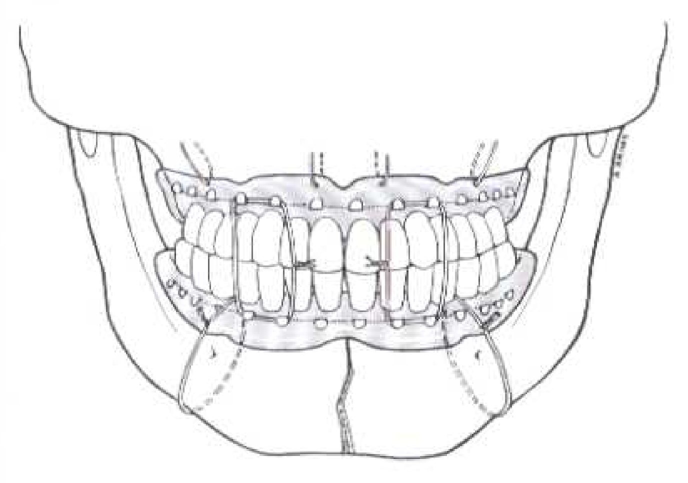


FIG. 5-52

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

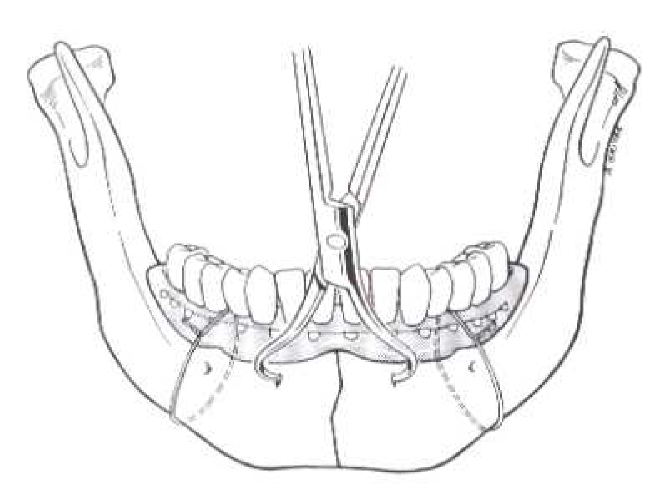


FIG. 5-53

Two miniplates are necessary for stable fixation in this area. (If there is not enough mandibular height to accommodate two miniplates, then a mandibular reconstruction plate or bone grafting technique is recommended.) The first miniplate is placed, using at least a four-hole plate. This is applied along the upper half of the mandible across the fracture. It is carefully bent to shape and applied by using either monocortical or bicortical screws because there are no teeth and the inferior alveolar nerves are not at risk in the symphyseal area.

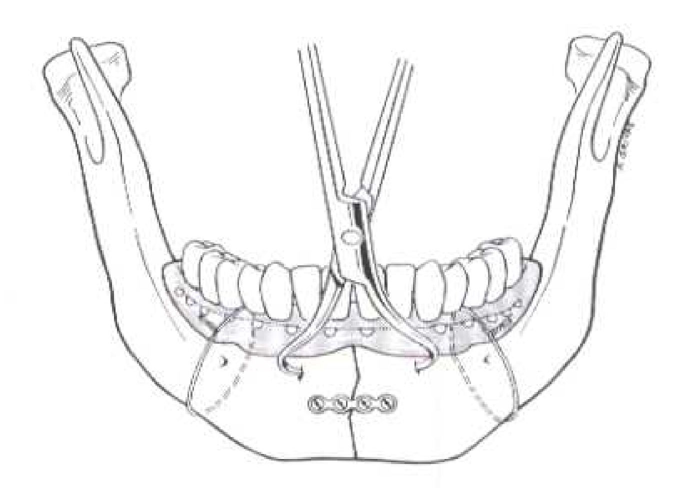


FIG. 5-54

The second miniplate is applied along the inferior ideal osteosynthesis line of Champy, which is above the inferior border, by using at least a four-hole plate. Monocortical or bicortical screws may be used. In the symphyseal region, two miniplates are necessary to overcome the torsional forces acting on this area.

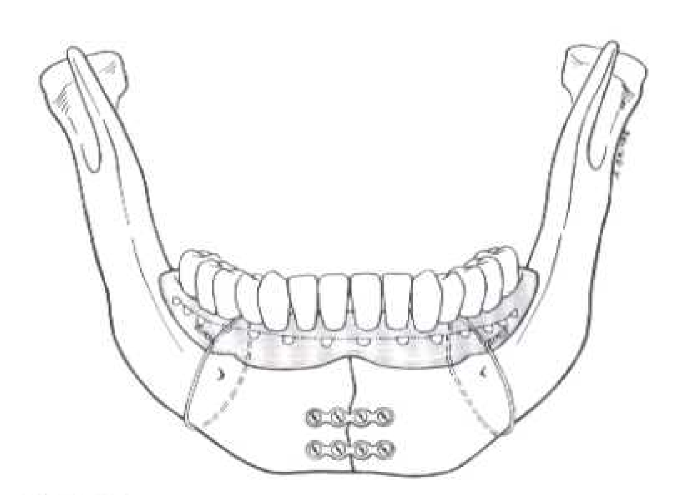


FIG. 5-55

The towel clip is removed, and the wound is irrigated, drained, and closed. IMF may now be removed.

THREE-DIMENSIONAL PLATE FIXATION

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 71

NOTE: *It is imperative when using the three-dimensional plate for mandibular fracture repair that plates of the proper thickness and size be used. The 1.0-mm thick plate is used with 2.0-mm screws. A three-dimensional microplate should not be used for mandibular repair.*

Occlusion is established using dentures or splints. (Some experienced surgeons perform miniplate fixation in this situation without using splints; however, establishing the occlusal relationship provides a more dependable outcome, particularly when the patient has more than one fracture site.) For three-dimensional plate fixation, an intraoral exposure is generally used.

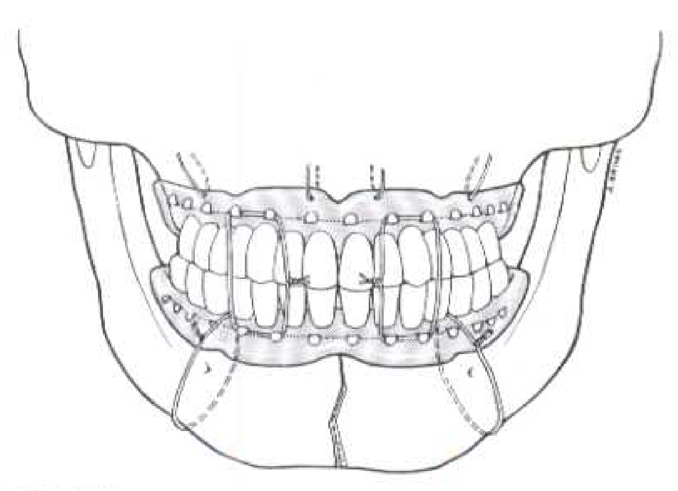


FIG. 5-56

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

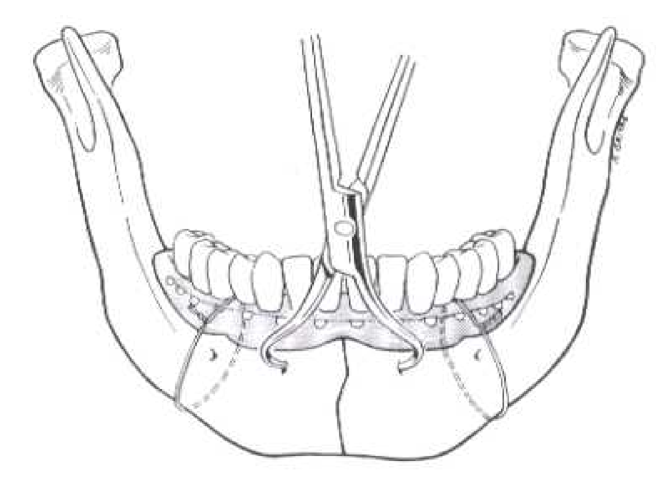


FIG. 5-57

A 2 x 2 (square four-hole) three-dimensional plate is positioned so that the horizontal crossbars are perpendicular to the fracture and the vertical crossbars are parallel to the fracture. Monocortical screws are placed in the two superior holes, although bicortical screws are safe in the edentulous symphysis. The two inferior screws are now placed. These similarly may be either monocortical or bicortical.

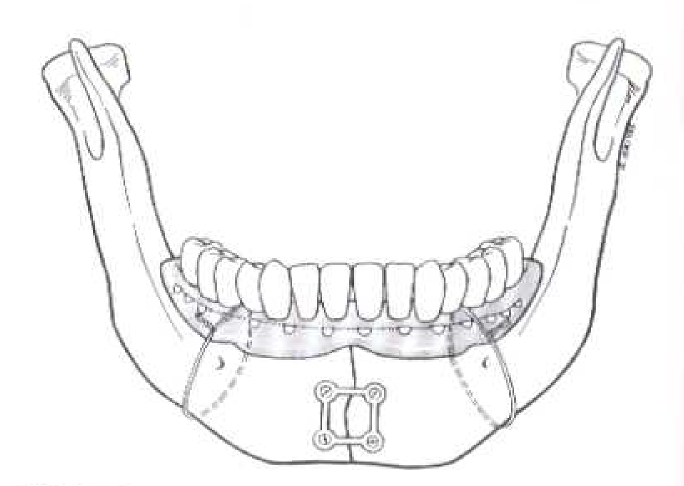


FIG. 5-58

The towel clip is removed, and the wound is irrigated, drained, and closed. IMF may now be removed.

EDCP

Key Principles	pp. 44, 66
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

The occlusal relationship is first established using dentures or splints. The fracture is generally exposed extraorally.

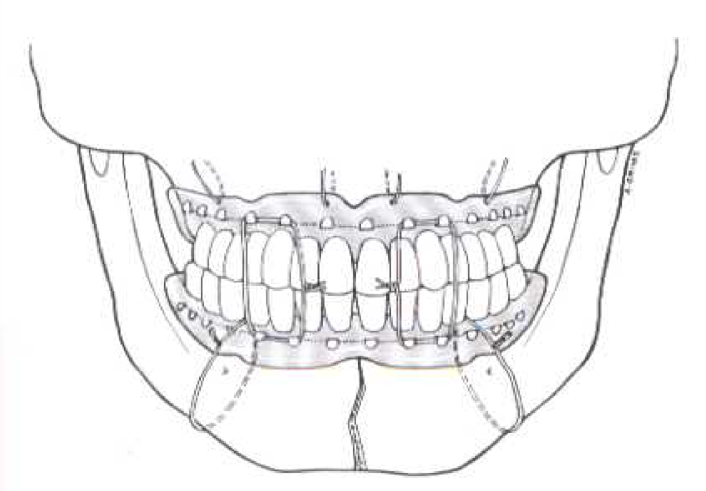


FIG. 5-59

When using an EDCP, the mandibular reduction pliers with side rollers for superior precompression is recommended. This is fixed to the inferior border of the mandible. Horizontal precompression is first applied, followed by vertical precompression with the rollers. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

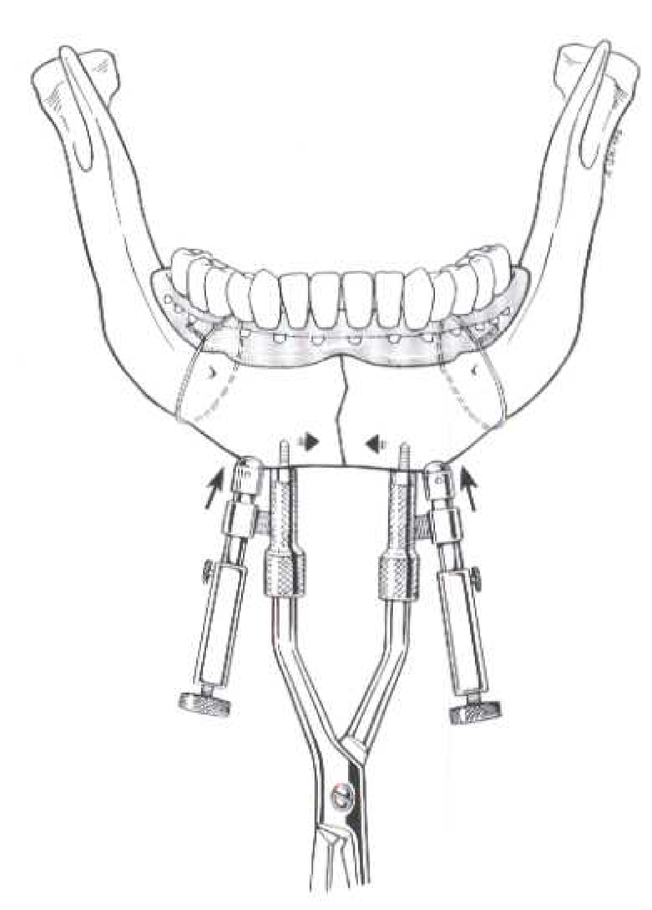


FIG. 5-60

An appropriate EDCP is selected. Because the EDCP has a top and a bottom, care must be used to make certain that this plate is not applied upside down. **The diagonal holes should point superiorly toward the fracture line!** A template is usually bent to shape first, and the plate is carefully bent to match the template and then, ultimately, the bone. After precise bending to match the mandibular contour has been completed, the plate is positioned and held in place with a plate-holding forceps. First, two horizontal compression screws are placed bicortically, positioning them eccentrically away from the fracture to produce horizontal compression. The locking screw on the reduction pliers is released.

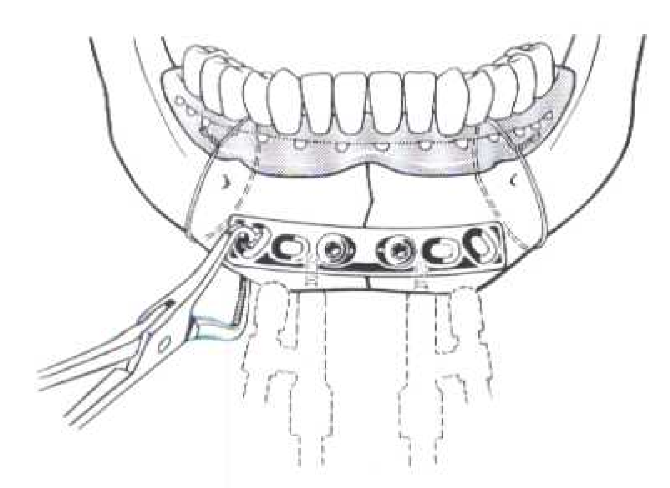


FIG. 5-61

The two superiorly directed compression screws are then placed bicortically, but only after the horizontal compression screws have been fully tightened. These are positioned inferiorly so that compression is directed toward the alveolar border of the fracture. The reduction pliers are then removed.

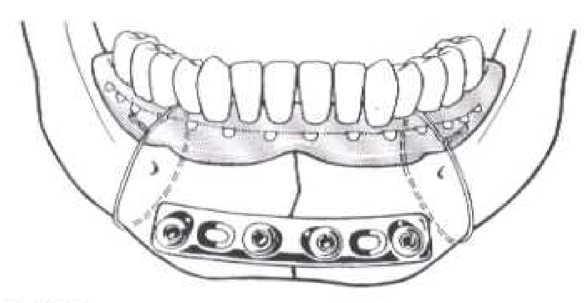


FIG. 5-62

Additional screws (when more than a four-hole plate has been used) are placed neutrally.

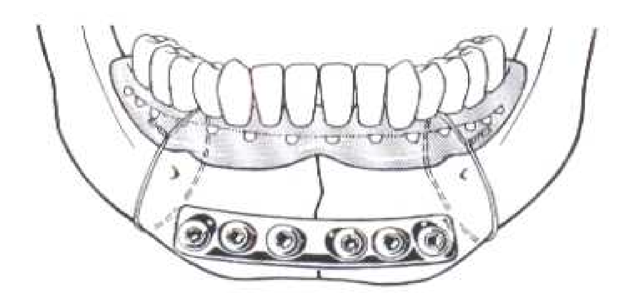


FIG. 5-63

The wound is irrigated, drained, and closed. IMF may now be removed.

MANDIBULAR RECONSTRUCTION PLATE

Key Principles	pp. 46, 68 (61, 62)
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

NOTE: The mandibular reconstruction plate provides excellent stability, so much so that it can replace defective areas. It is thus excellent for adding stability when the underlying fractured bone is atrophic and weak. A long plate with numerous fixation points puts the weak area to rest, and it adds to the stability of the repair and, therefore, increases the likelihood of healing.

Occlusion is first established with dentures or splints when possible. An intraoral or an extraoral approach may be used. In the pencil-thin mandible, the periosteum is left intact to whatever degree is possible to minimize devascularization of bone.

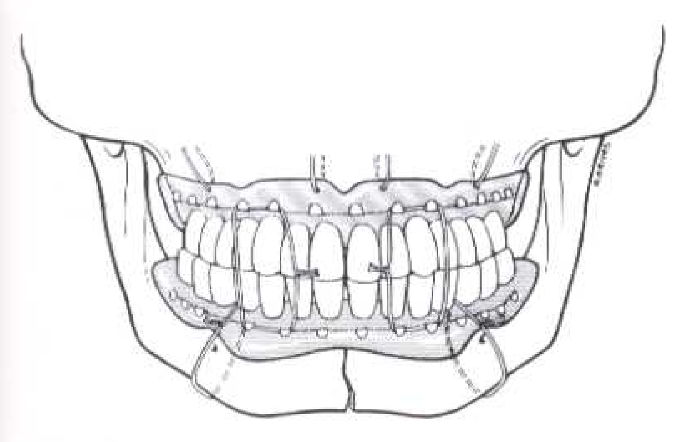


FIG. 5-64

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

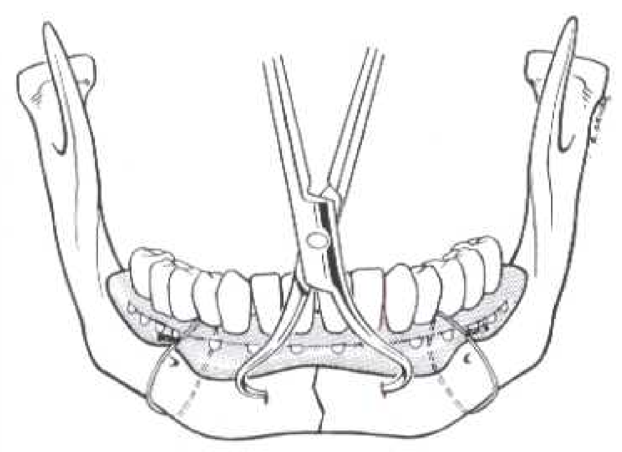


FIG. 5-65

(Optional) A mandibular reduction pliers with side rollers for superior compression may be applied along the inferior border. However, this may not be desirable in the thin atrophic mandible. If they are used, horizontal precompression is applied, the lock screw is tightened, and the rollers are used to compress the superior borders of the fragments. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

A reconstruction plate is selected and applied, taking care to bend it as precisely as possible to the template and to the bone. A plate-holding forceps helps to hold the plate in position for screw placement. At least four or five bicortical screws on each side of the fracture provide excellent structural support for the weak atrophic bone. The central screws may be placed eccentrically away from the fracture for compression if desired, but only if the mandibular height is only slightly higher than the plate; the remaining screws are placed neutrally.

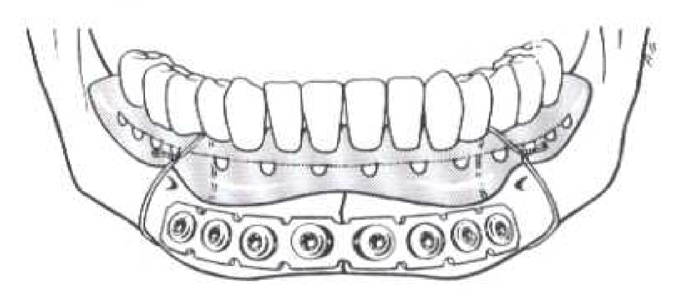


FIG. 5-66

Otherwise, all screws are positioned neutrally.

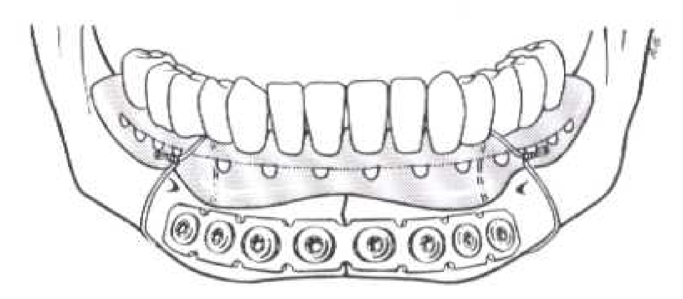


FIG. 5-67

The wound is irrigated, drained, and closed. IMF may now be removed.

LAG SCREW FIXATION

Key Principles	pp. 47, 50
Surgical Approaches	
Intraoral	p. 71

NOTE: *When using this technique, long screws (38–44 mm) must be available.*

Occlusion is first established with dentures or splints. The fracture is exposed intraorally.

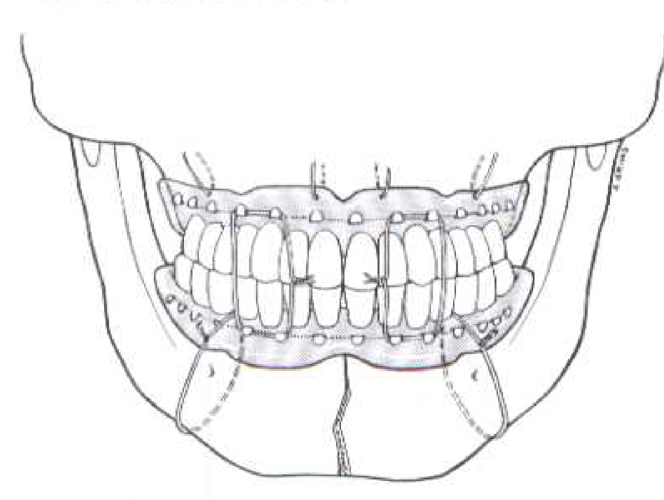


FIG. 5-68

A small notch is drilled on either side of the fracture so that the prongs of a modified towel clip can grasp the bone. The towel clip is applied across the fracture for prereduction and precompression.

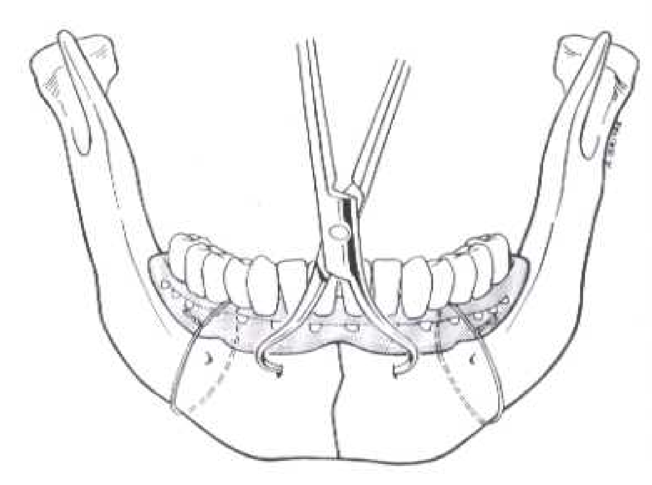


FIG. 5-69

Using a drill guide, a gliding hole (generally, 2.7 mm) is drilled from lateral to medial through one fragment, near the midportion.

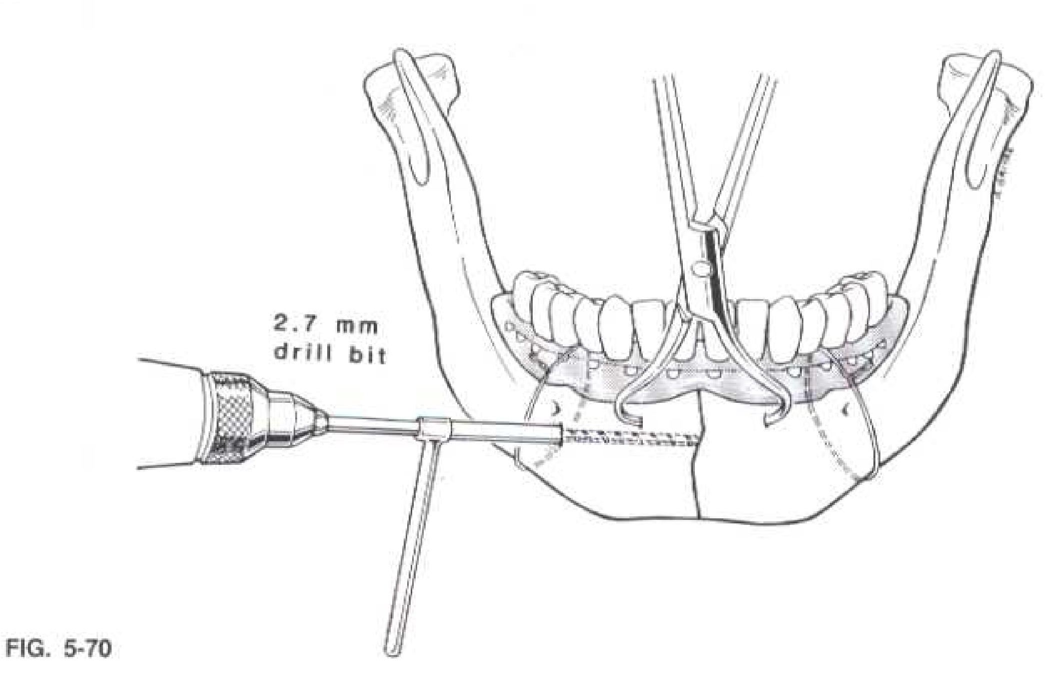


FIG. 5-70

A drill guide can now be placed into the gliding hole, and the second fragment is drilled (generally, 2.0 mm). A countersink is used to enlarge the first hole for proper seating of the screw head.

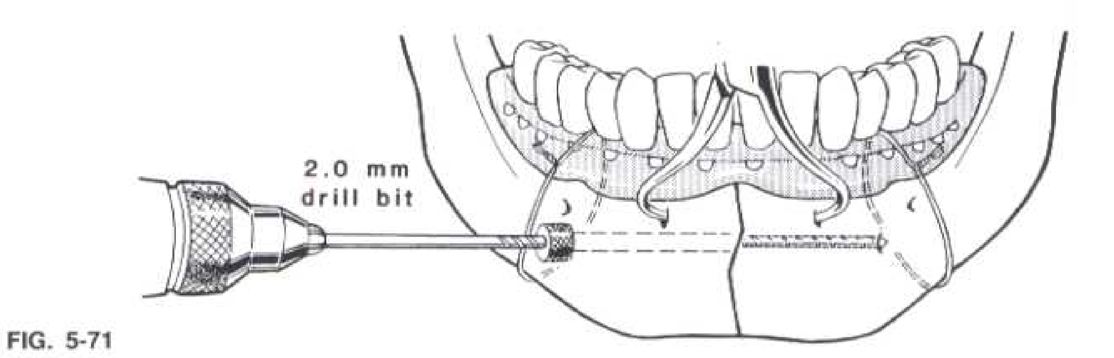


FIG. 5-71

The hole is measured with a depth gage. When using a nonself-tapping system, the distal hole is tapped.

An appropriate-length screw is placed and tightened.

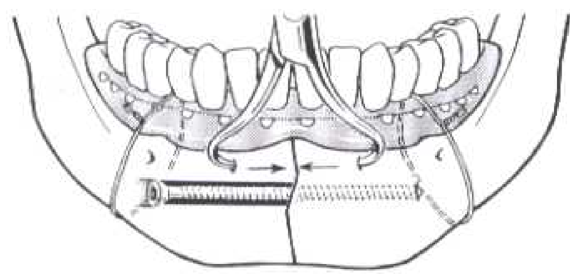


FIG. 5-72

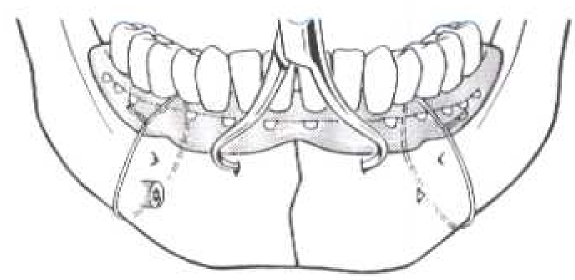


FIG. 5-73

A second lag screw is placed below the first by repeating the same process. (If there is not enough mandibular height to accommodate two lag screws, then a mandibular reconstruction plate (or bone grafting technique) is recommended.)

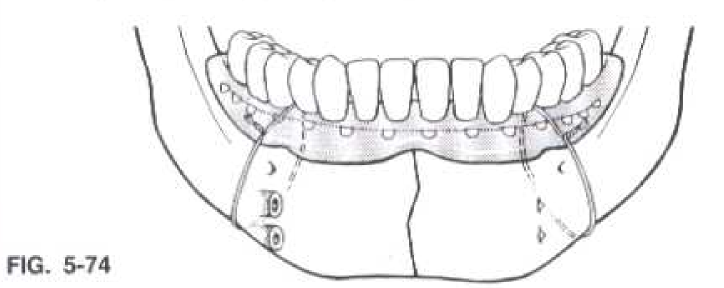


FIG. 5-74

The wound is irrigated, drained, and closed. IMF may now be removed.

CHAPTER 3

Parasymphysis: Dentulous (Nonoverlapping)

In the parasymphyseal area, compared with the symphysis, the presence of the inferior alveolar nerve adds to the technical difficulty of plate application. Although the fracture can be easily exposed through an intraoral approach, plate application (particularly compression plate application) may lead to stretching of the mental nerve as it leaves the mandible. Of course, care must be taken not to tear or transsect this nerve. When an intraoral exposure is used, it is sometimes possible to place all screws through the incision. However, transbuccal placement of some posterior screws may be necessary.

TENSION BAND ARCH BAR AND COMPRESSION PLATE

Key Principles	pp. 43, 62
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

The tension band arch bar is first applied to the teeth across the fracture site, and proper occlusion is reestablished. To serve as a tension band, the arch bar must effectively pull the alveolar portion of the fracture together. The fracture is exposed either intraorally or extraorally.

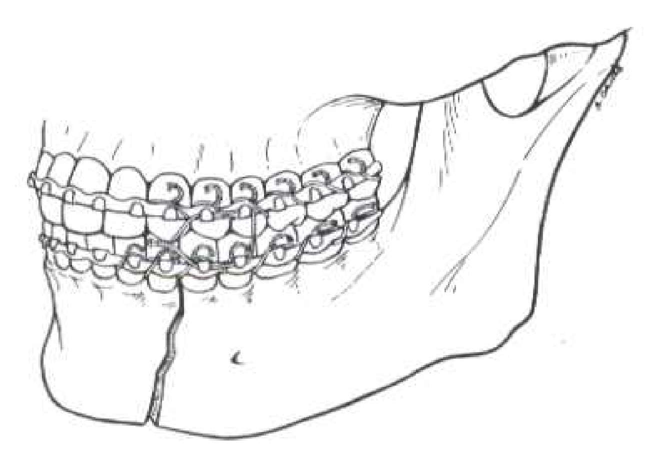


FIG. 5-75

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

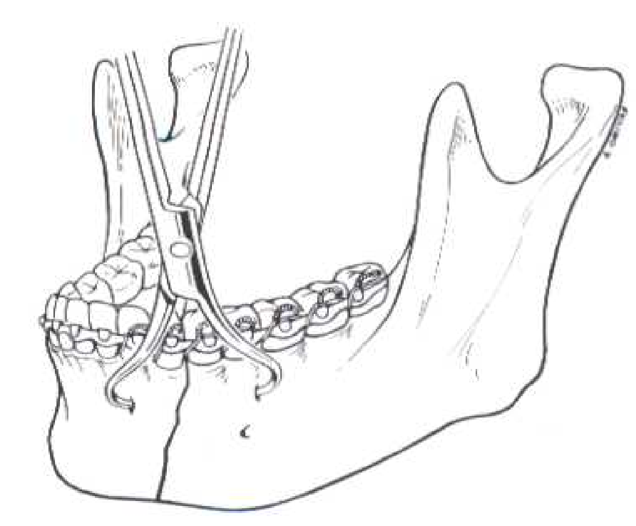


FIG. 5-76

(Optional) A mandibular reduction pliers may be applied along the inferior border of the mandible. Using these pliers, the fragments are reduced, and precompression is applied. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

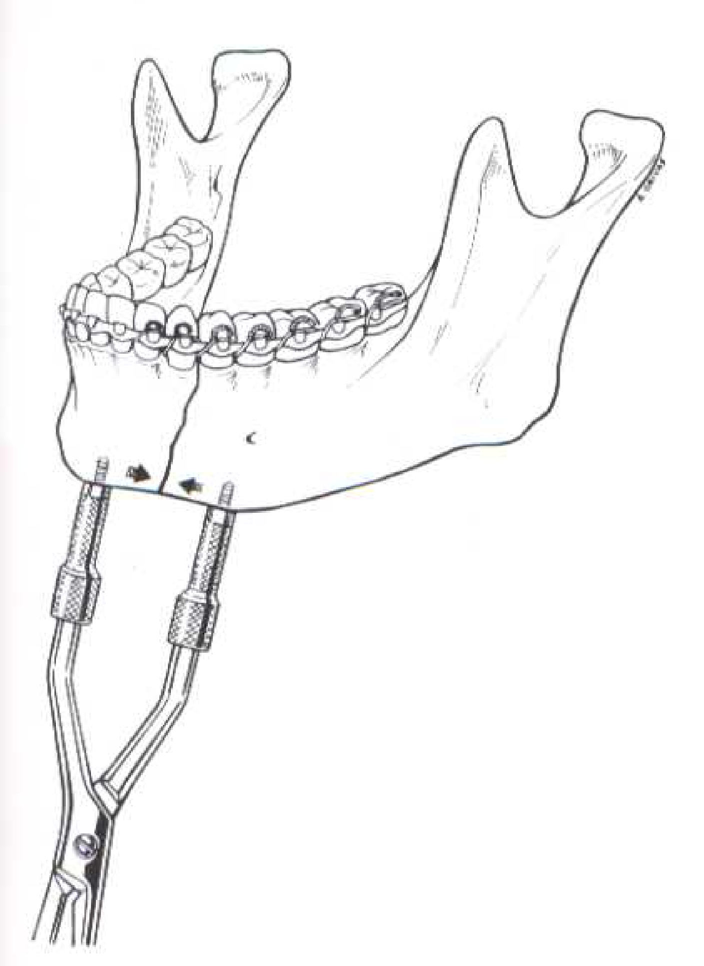


FIG. 5-77

An appropriate compression plate is selected, using at least a four-hole plate. This is fixed along the inferior third of the mandible. Be sure to position the plate below the tooth roots and the inferior alveolar nerve. The plate may be held in place with plate-holding forceps after precise bending to the mandibular contour has been successfully completed, usually bending a template first, and then bending the plate.

Plate application is completed by using two bicortical compression screws eccentrically placed away from the fracture

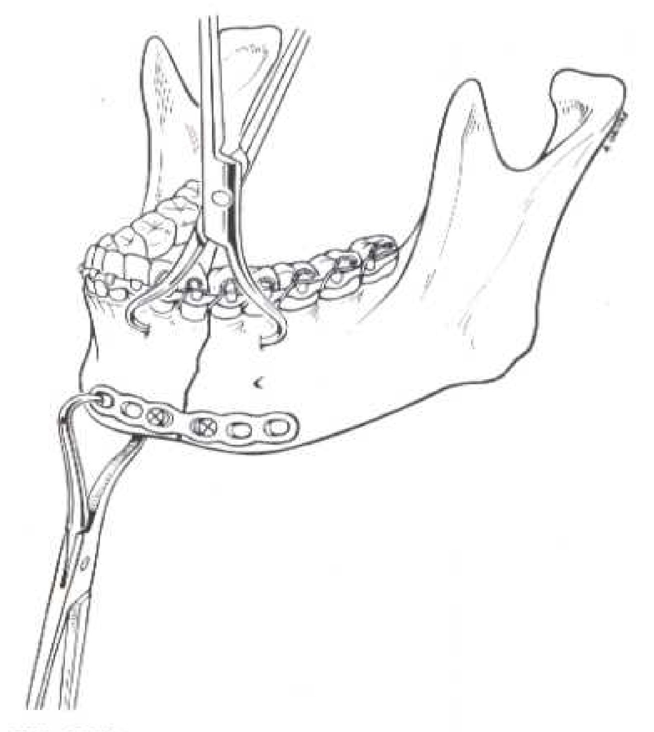


FIG. 5-78

and two to six bicortical neutral screws (obviously depending on the length of the plate). When a mandibular reduction forceps has been used, the locking screw is released after the two compression screws have been placed, and the pliers may be removed completely at any time after four screws have been placed.

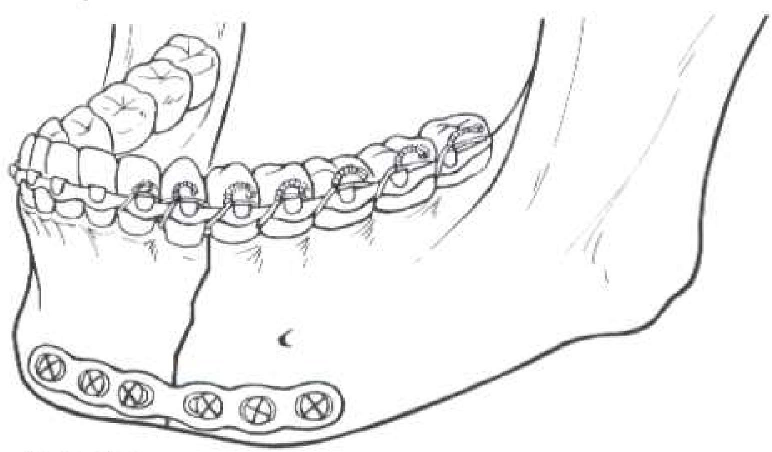


FIG. 5-79

The wound is irrigated, drained, and closed. IMF may now be released.

TENSION BAND MINIPLATE AND COMPRESSION PLATE

Key Principles	pp. 42, 43, 61, 62
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

Occlusion is established, but a tension band arch bar has not been placed or is inadequate as a tension band. The fracture is exposed either intraorally or extraorally.

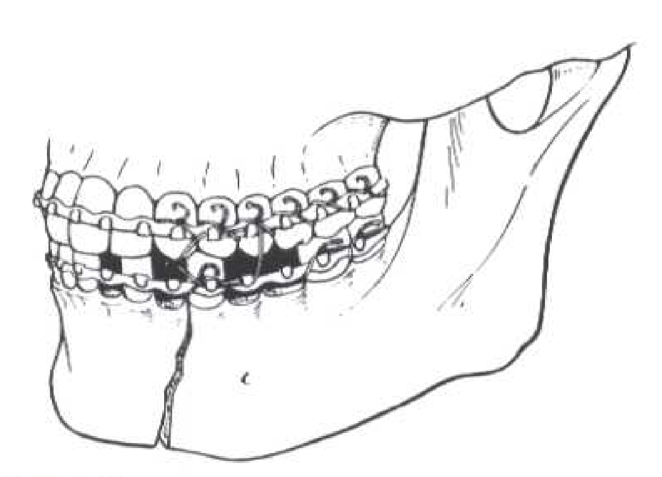


FIG. 5-80

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

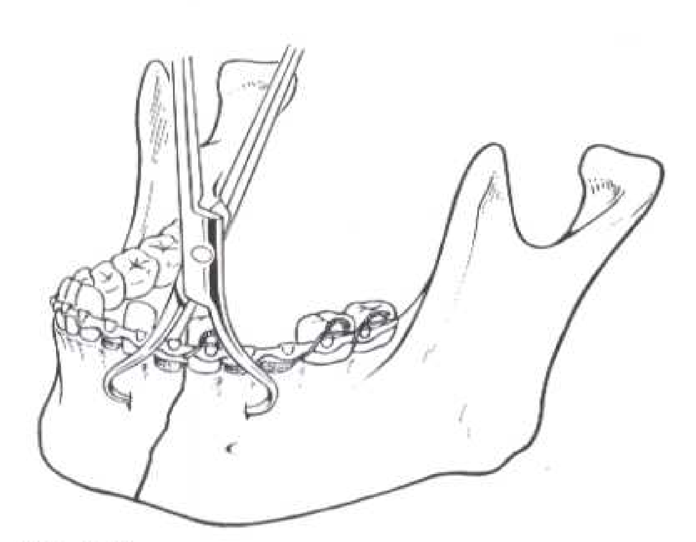


FIG. 5-81

(Optional) A mandibular reduction pliers with side rollers may be fixed to the inferior border of the mandible for reduction and precompression. This generally requires an extraoral approach. Rollers must be used because the tension band is inadequate; otherwise, the alveolar portion of the fracture will be distracted. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

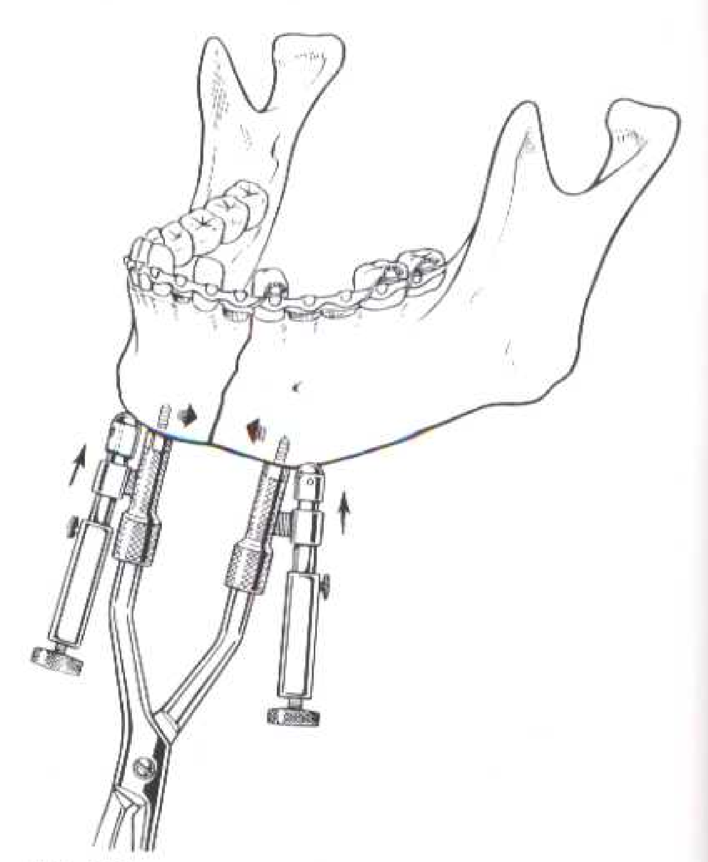


FIG. 5-82

A tension band miniplate is applied by using monocortical screws along the tension line of Champy, using at least a four-hole plate. The miniplate must be placed 1.5 to 2 crown heights below the gingival margin to avoid the tooth roots. If the plate can be placed in its entirety anterior to the mental foreman, then the nerve is not at risk. However, the canine root tip extends further inferiorly than the other roots, and care must be used to avoid placement of screws into it. A longer plate may be used so that no screw is necessary over the canine root, or the plate may be positioned slightly more inferiorly.

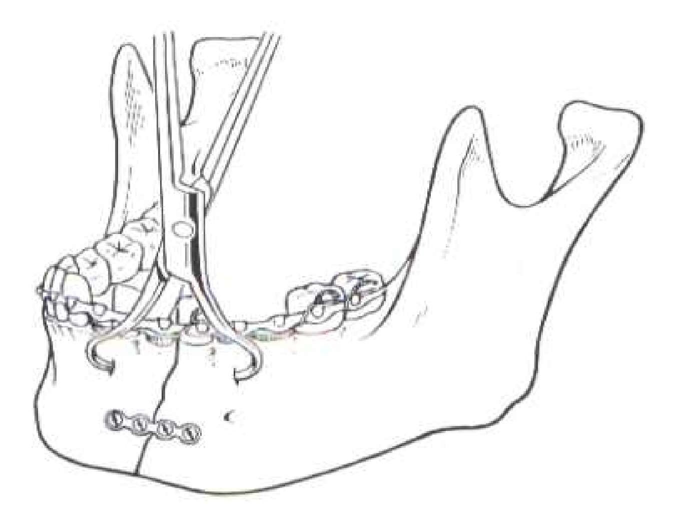


FIG. 5-83

An appropriate compression plate is selected, using at least a four-hole plate. This is fixed along the inferior third of the mandible. Be sure to position the plate well below the tooth roots and the inferior alveolar nerve. The plate is held in position with plate-holding forceps after precise bending to the mandibular contour has been successfully completed, usually bending a template first and then bending the plate.

Plate application is completed by using two bicortical compression screws eccentrically placed away from the fracture

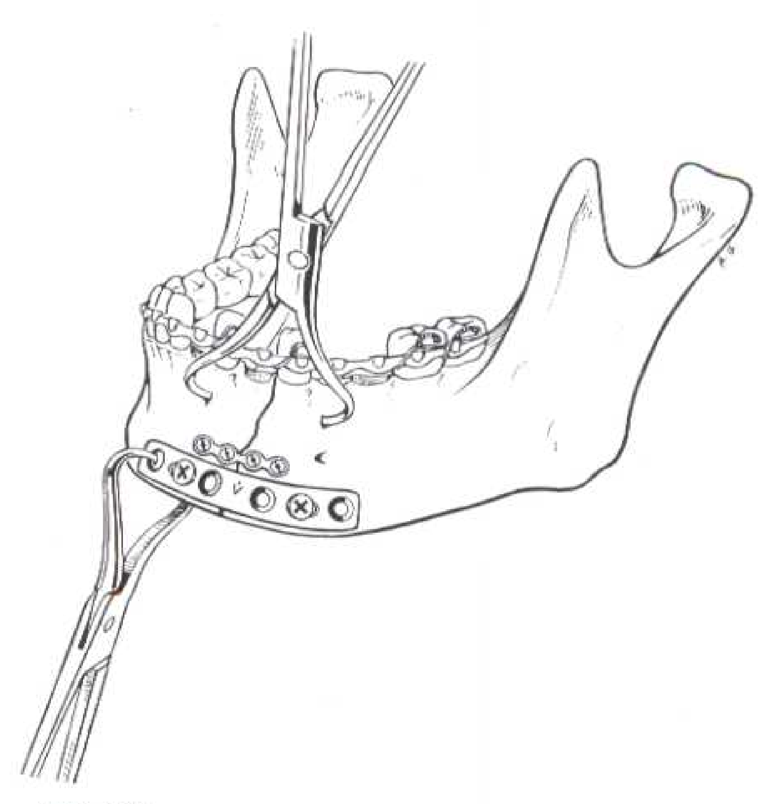


FIG. 5-84

and two to six bicortical neutral screws (obviously depending on the length of the plate). When a mandibular reduction forceps has been used, the locking screw is released after the two compression screws have been placed, and the pliers may be removed completely any time after four screws have been placed.

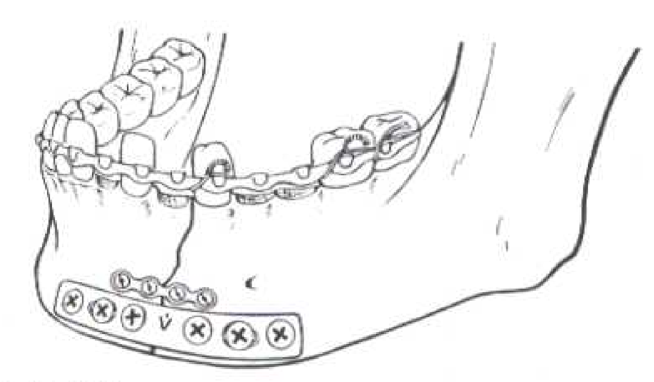


FIG. 5-85

The wound is irrigated, drained, and closed. IMF may now be released.

MINIPLATE FIXATION

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 71

Occlusion is established using loops or arch bars for IMF. For miniplate fixation, an intraoral exposure is generally used.

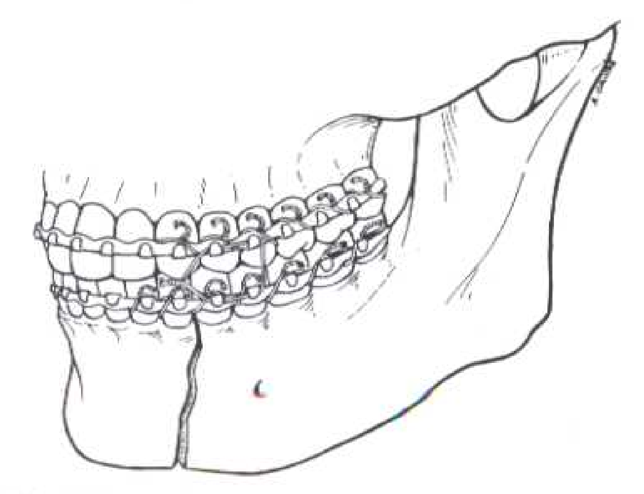


FIG. 5-86

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

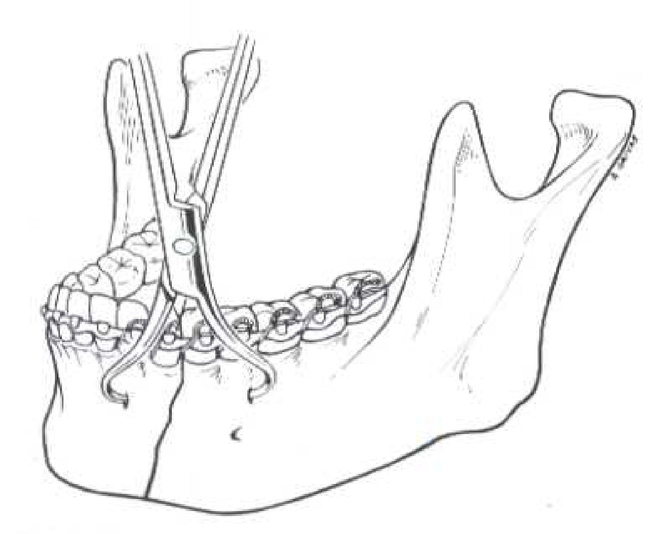


FIG. 5-87

Two miniplates are necessary for stable fixation in the parasymphyseal region. The first miniplate is placed by using monocortical screws along the tension line of Champy, using at least a four-hole plate. The miniplate must be placed 1.5 to 2 crown heights below the gingival margin to avoid the tooth roots. If the plate can be placed in its entirety anterior to the mental foramen, then the nerve is not at risk. However, the canine root tip extends further inferiorly than the other roots, and care must be used to avoid placement of screws into it. A longer plate may be used so that no screw is necessary over the canine root, or the plate may be positioned slightly more inferiorly.

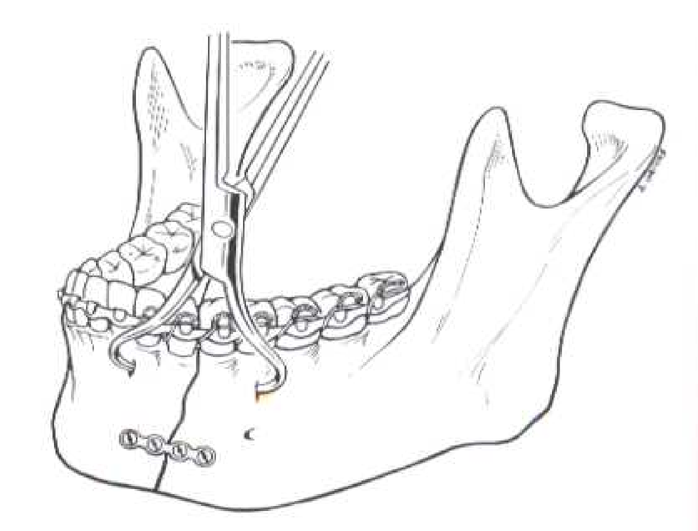


FIG. 5-88

The second miniplate is applied by using monocortical screws (although inferiorly, bicortical screws may be used safely) along the inferior ideal osteosynthesis line. This is above the inferior border of the mandible. In the parasymphyseal region, two miniplates are necessary to overcome the torsional forces acting on this area.

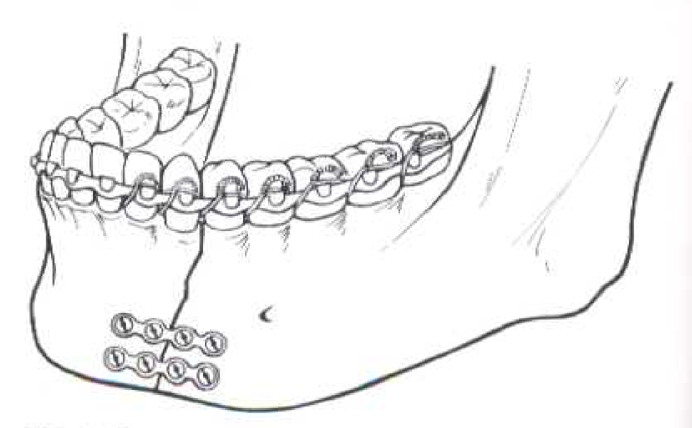


FIG. 5-89

The towel clip is removed, and the wound is irrigated, drained, and closed. IMF may now be released.

THREE-DIMENSIONAL PLATE FIXATION

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 71

NOTE: *It is imperative when using the three-dimensional plate for mandible fracture repair that plates of the proper thickness and size be used. The 1.0-mm thick plate is used with 2.0-mm screws. A three-dimensional microplate should not be used for mandibular repair.*

Occlusion is established using loops or arch bars for IMF. For three-dimensional plate fixation, an intraoral exposure is generally used.

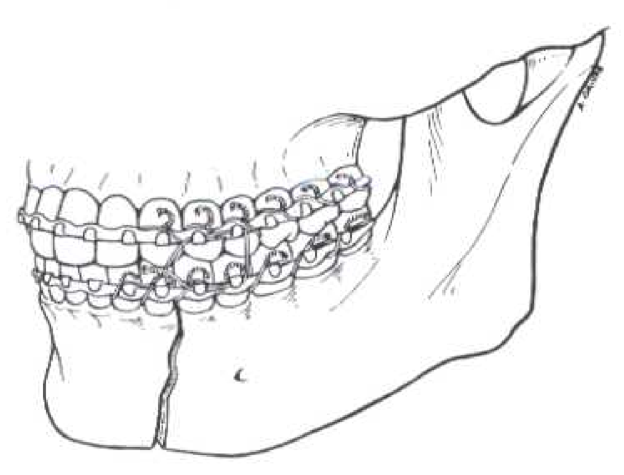


FIG. 5-90

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

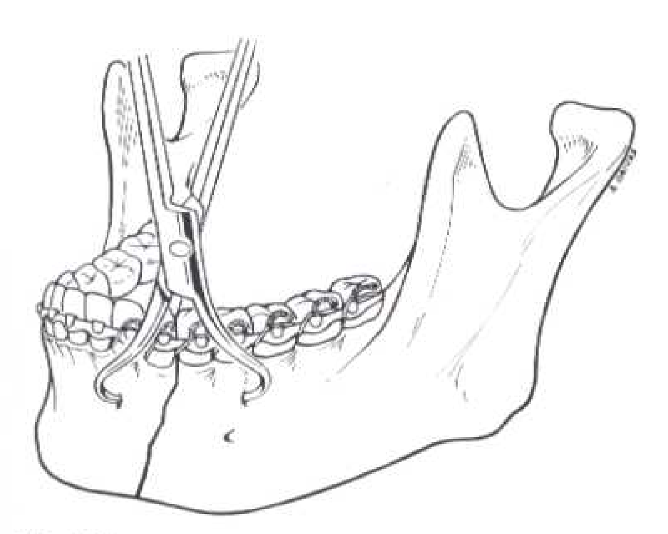


FIG. 5-91

A 2 x 2 (square four-hole) three-dimensional plate is positioned so that the horizontal crossbars are perpendicular to the fracture and the vertical crossbars are parallel to the fracture. Monocortical screws are placed in the two superior holes, making certain that the superior screws are at least 5 mm below the tooth roots. This should be between the tooth roots and the level of the inferior alveolar nerve, 1.5 to 2 crown heights below the gingival margin, although in the parasymphyseal region it is actually anterior to the mental foramen, below the canine root tip. The two inferior screws are now placed. These are positioned below the level of the inferior alveolar nerve and, therefore, may be either monocortical or bicortical.

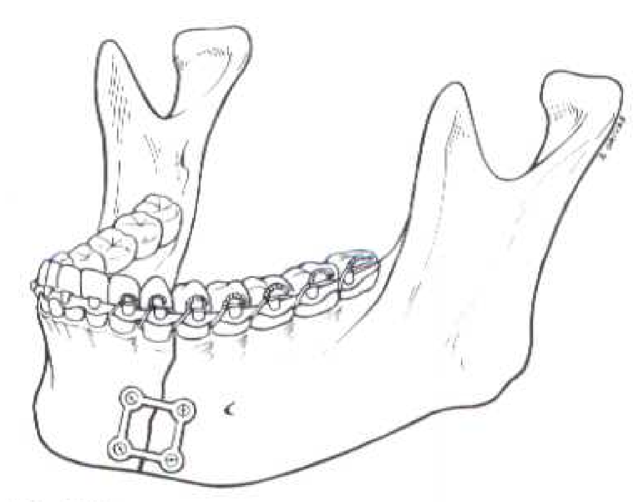


FIG. 5-92

The towel clip is removed, and the wound is irrigated, drained, and closed. IMF may now be released.

EDCP

Key Principles	pp. 44, 66
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

NOTE: *This is not the preferred or recommended technique by the authors for this situation. The authors believe that, when it is possible, a tension band technique is preferred if a compression plate is to be used.*

Occlusion is established, but a tension band arch bar has not been placed or is inadequate. The fracture is generally exposed extraorally.

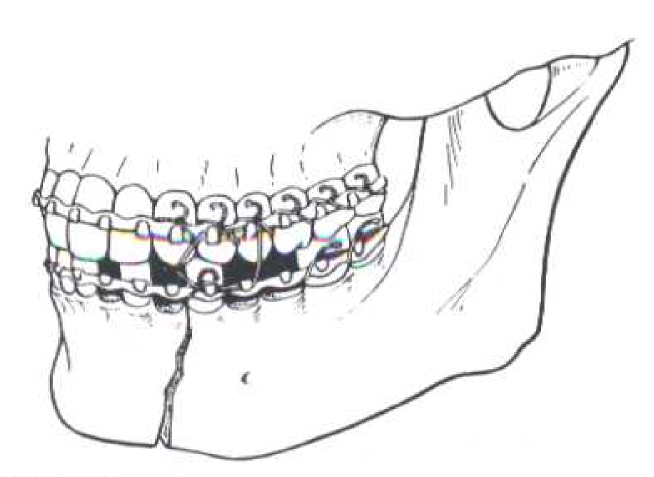


FIG. 5-93

When using an EDCP, the alveolar border (traction side) of the mandible must be precompressed. A modified towel clip may be used, although the mandibular reduction pliers with side rollers for superior precompression is recommended. This is fixed to the inferior border of the mandible. Horizontal precompression is first applied, followed by vertical precompression with the rollers. Care should be used to place the screws that hold the the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

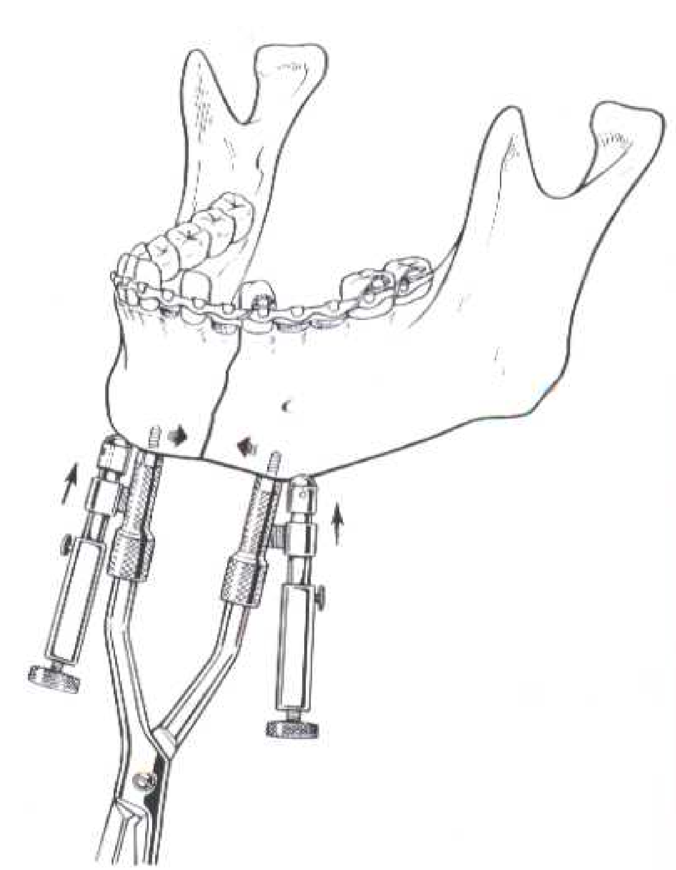


FIG. 5-94

An appropriate EDCP is selected. Because the EDCP has a top and a bottom, care must be used to make certain that this plate is not applied upside down. **The diagonal holes should point superiorly toward the fracture line!** A template is usually bent to shape first, and the plate is carefully bent to match the template and then, ultimately, the bone. After precise bending to match the mandibular contour has been completed, the plate is positioned and held in place with a plate-holding forceps. First, two horizontal compression screws are placed bicortically, positioning them eccentrically away from the fracture to produce horizontal compression. The locking screw on the reduction pliers is released.

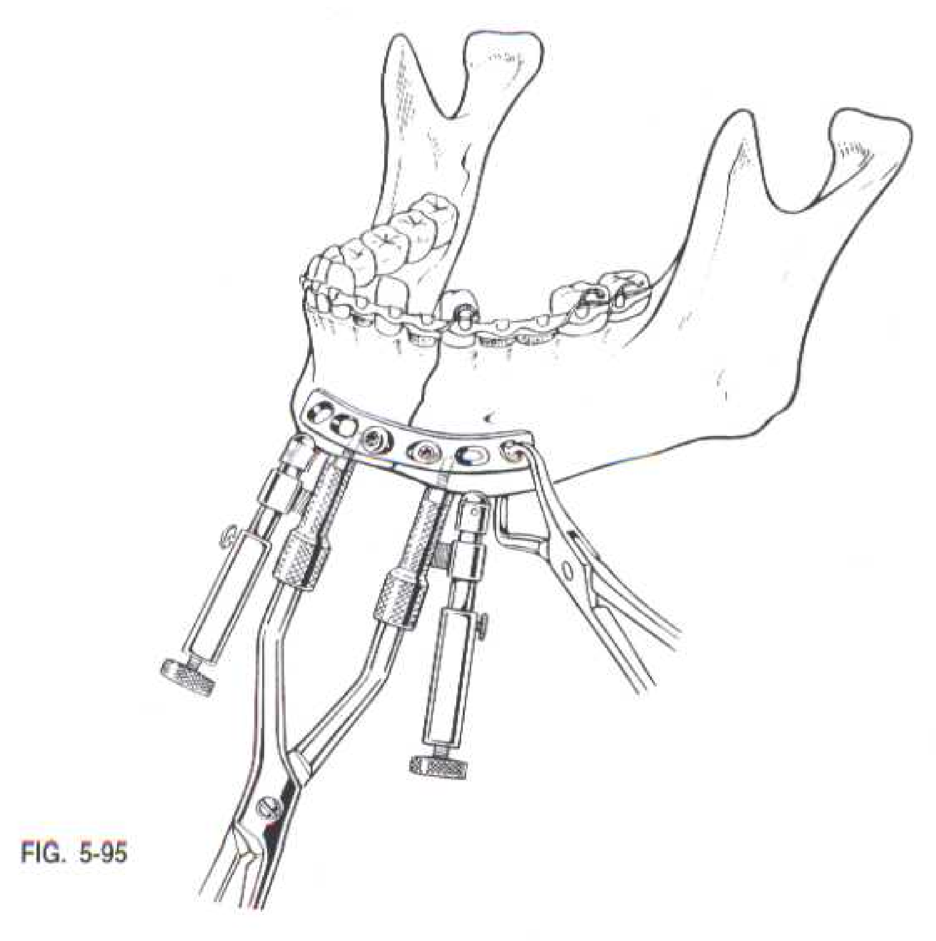


FIG. 5-95

The two superiorly directed compression screws are then placed bicortically, but only after the horizontal compression screws have been fully tightened. These are positioned inferiorly so that compression is directed toward the alveolar border of the fracture. The reduction pliers are then removed.

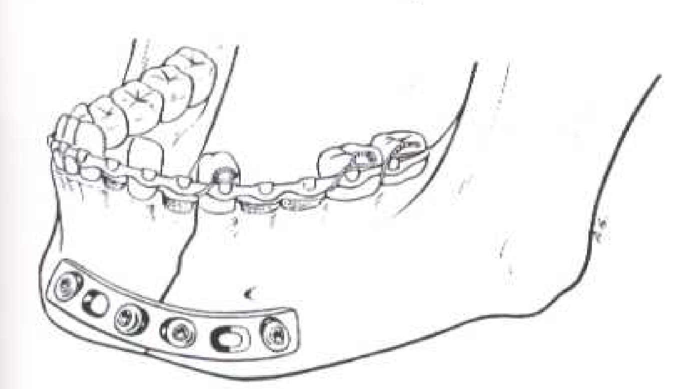


FIG. 5-96

Additional screws (when more than a four-hole plate has been used) are placed neutrally.

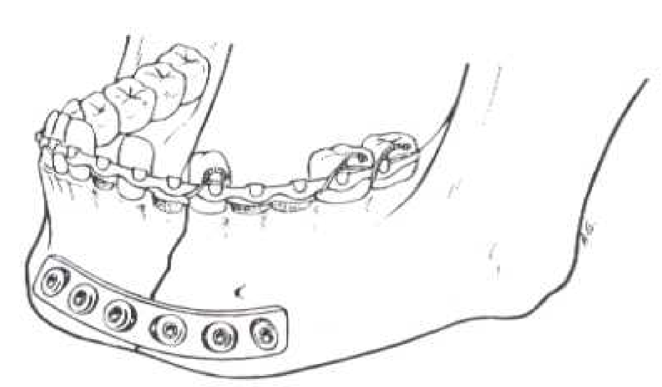


FIG. 5-97

The wound is irrigated, drained, and closed. IMF may now be released.

MANDIBULAR RECONSTRUCTION PLATE

Key Principles	pp. 46, 68 (61, 62)
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

Occlusion is first established by using a tension band arch bar or loops. The fracture is exposed either intraorally or extraorally.

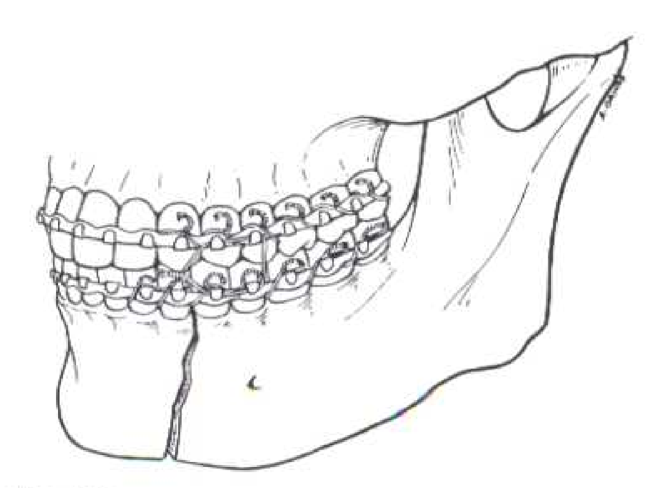


FIG. 5-98

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture. The towel clip is then used to precompress the fracture.

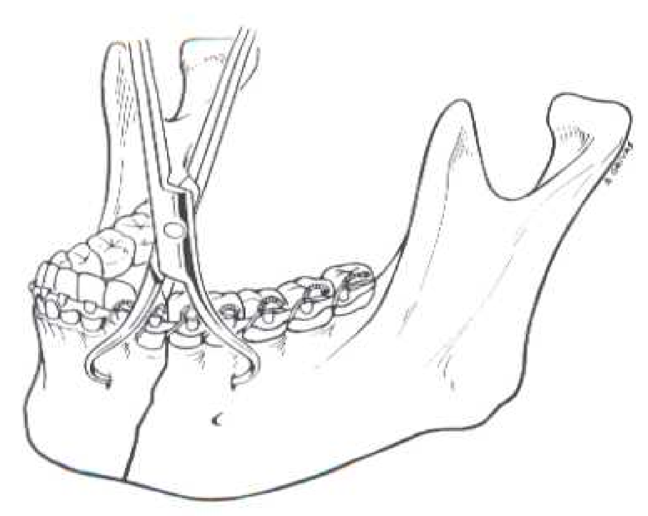


FIG. 5-99

(Optional) A mandibular reduction pliers may be applied along the inferior border of the mandible. No rollers are necessary if a tension band arch bar has been applied.

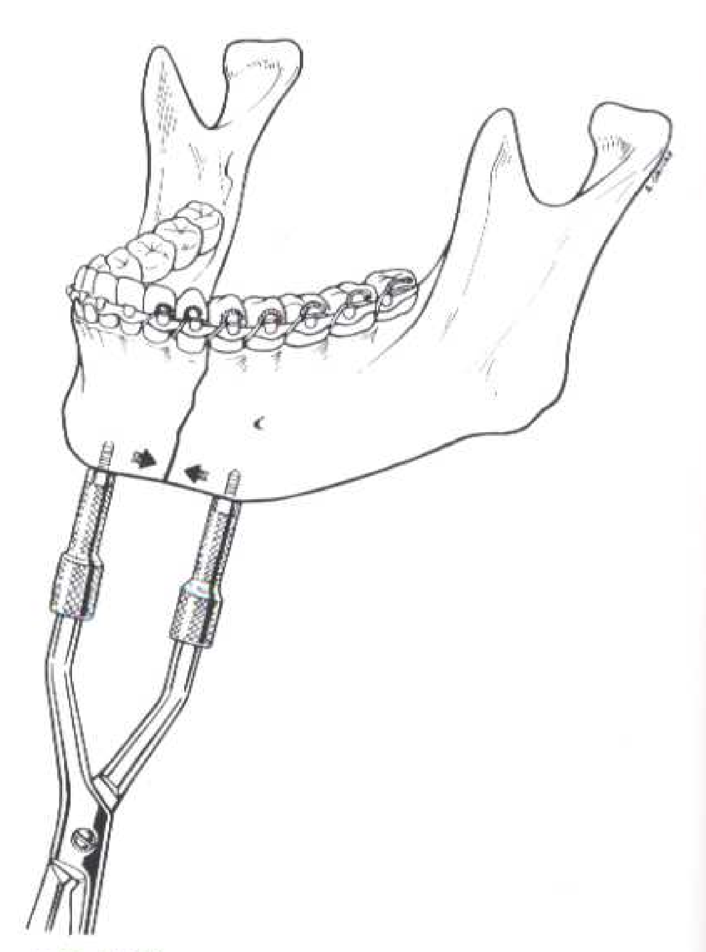


FIG. 5-100

If no tension band has been applied, then superior compression using the side rollers is mandatory if the compression pliers are used. Otherwise, compression of the inferior border will result in separation of the alveolar border. Using the reduction pliers, horizontal precompression can be applied. Tightening the rollers provides superiorly directed forces to compress the alveolar border when no tension band is present. Care should be used to place the screws that hold the pliers between the anticipated plate holes so that they do not interfere with plate application.

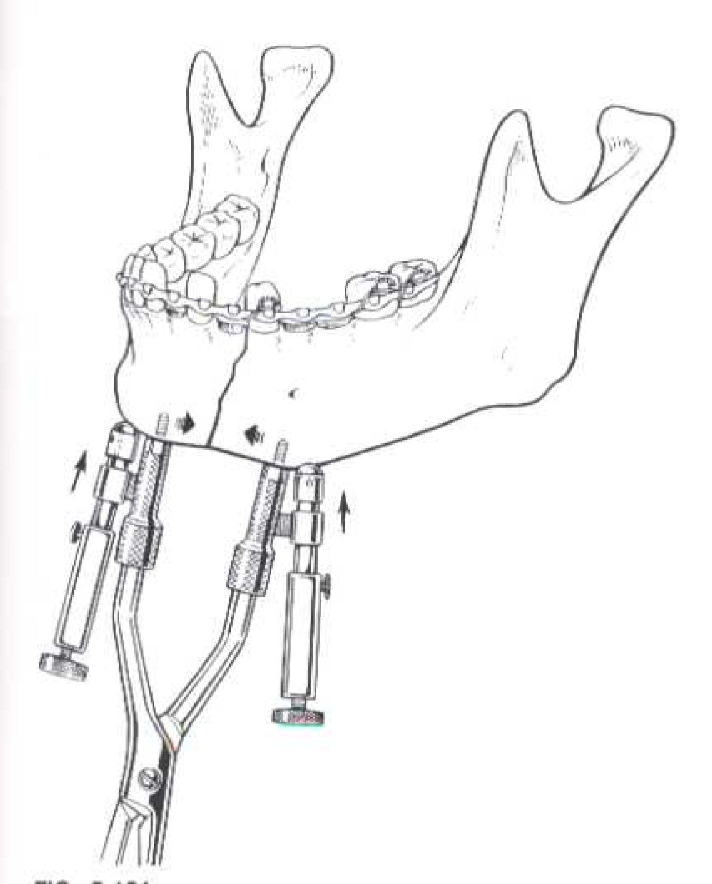


FIG. 5-101

(Optional) If no arch bar has been applied, a tension band miniplate may be applied by using monocortical screws along the tension line of Champy, using at least a four-hole plate. The miniplate must be placed 1.5 to 2 crown heights below the gingival margin to avoid the tooth roots. If the plate can be placed in its entirety anterior to the mental foramen, then the nerve is not at risk. However, the canine root tip extends further inferiorly than the other roots, and care must be used to avoid placement of a screw into it. A longer plate may be used so that no screw is necessary over the canine root, or the plate may be positioned slightly more inferiorly.

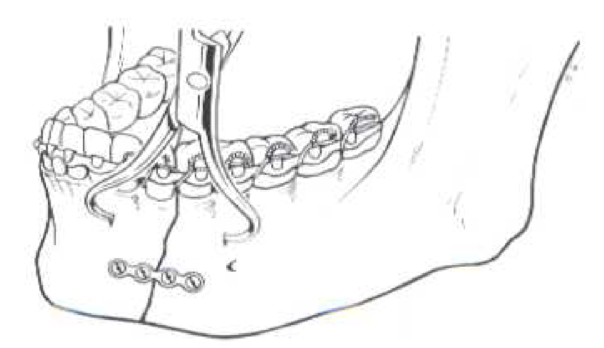


FIG. 5-102

A mandibular reconstruction plate with at least six holes is selected. A template is bent to match the mandibular contour, and the plate is carefully bent to match the template and, ultimately, the mandibular contour of the inferior mandibular border.

Bicortical screws are used. If a tension band has been placed, the first two screws can be placed eccentrically away from either side of the fracture to produce compression. The remaining screws are then placed neutrally.

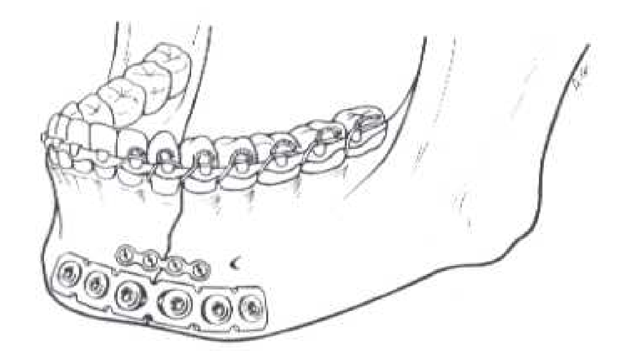


FIG. 5-103

When there is no tension band present, all screws are placed neutrally, placing at least three screws on each side of the fracture, although four or five on each side provide greater stability.

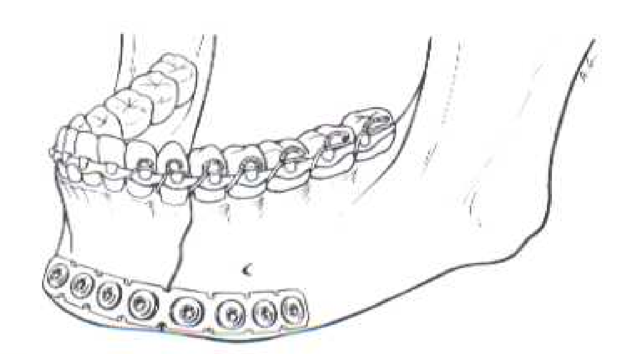


FIG. 5-104

The wound is irrigated, drained, and closed. IMF may now be released.

LAG SCREW FIXATION

Key Principles	pp. 47, 50
Surgical Approaches	
Intraoral	p. 71

NOTE: *When using this technique, long screws (38–44 mm) must be available.*

Although lag screws can be used to fix parasymphyseal fractures, this technique is more difficult here compared with the symphysis because there is less cortex to catch with the lag screw. The presence of the inferior alveolar nerve also adds to the technical difficulty.

The technique is the same as that for the symphysis, and the reader is referred to pages 160–161. An example of the final outcome is depicted here.

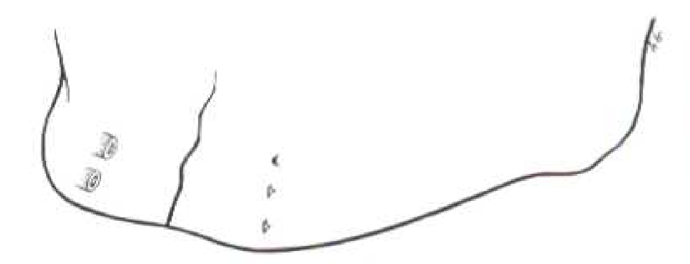


FIG. 5-105

CHAPTER 4

Parasymphysis: Edentulous (Nonoverlapping)

The absence of teeth does not negate the importance of establishing the proper relationship of the mandible and maxilla for function. If the patient has dentures, it is preferable to use these as the best guide to the patient's functional occlusion and, therefore, the proper position of the bone fragments. These can be modified to include arch bars to allow for the easy creation of the proper occlusal relationship. If the patient does not have dentures, it is recommended that the occlusal relationship be established with splints. If the bone is very atrophic, we recommend the use of a mandibular reconstruction plate or a bone grafting technique to increase the likelihood of achieving stability and, therefore, bony union.

In the parasymphyseal area, compared with the symphysis, the presence of the inferior alveolar nerve adds to the technical difficulty of plate application. Although the fracture can be easily exposed by an intraoral approach, plate application (particularly compression plate application) may lead to stretching of the mental nerve as it leaves the mandible. Of course, care must be taken not to tear or transsect this nerve. When an intraoral exposure is used, it is sometimes possible to place all screws through the incision. However, transbuccal placement of some posterior screws may be necessary.

TENSION BAND MINIPLATE AND COMPRESSION PLATE

Key Principles	pp. 42, 43, 61, 62
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

Occlusion is first established with dentures or splints. The fracture is exposed either intraorally or extraorally.

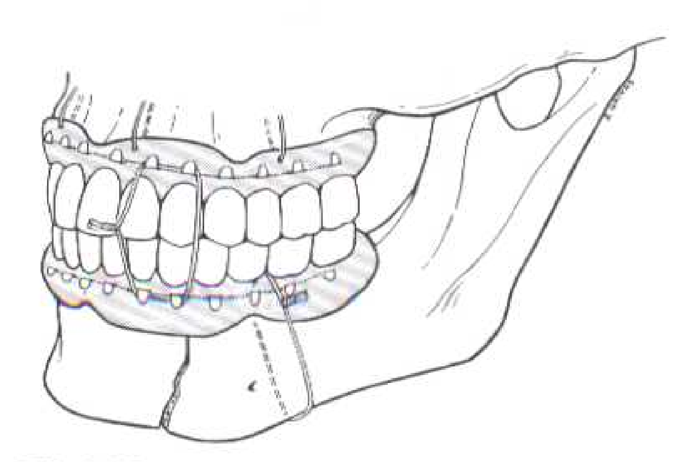


FIG. 5-106

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

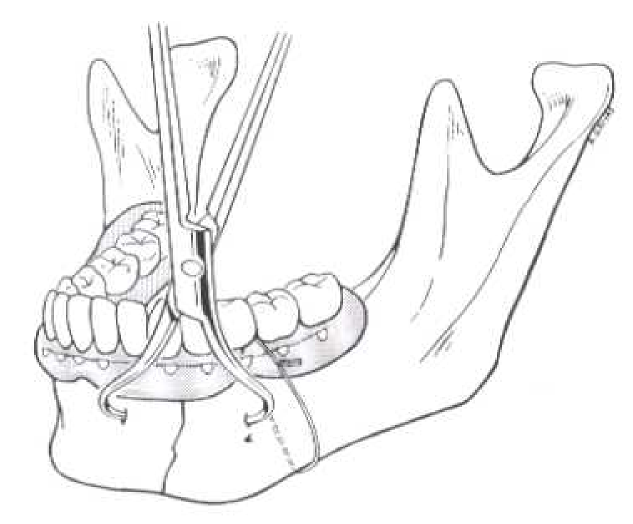


FIG. 5-107

(Optional) A mandibular reduction pliers with side rollers may be fixed to the inferior border of the mandible for reduction and precompression. This generally requires an extraoral approach. Rollers must be used because there is no tension band; otherwise, the alveolar portion of the fracture will be distracted. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

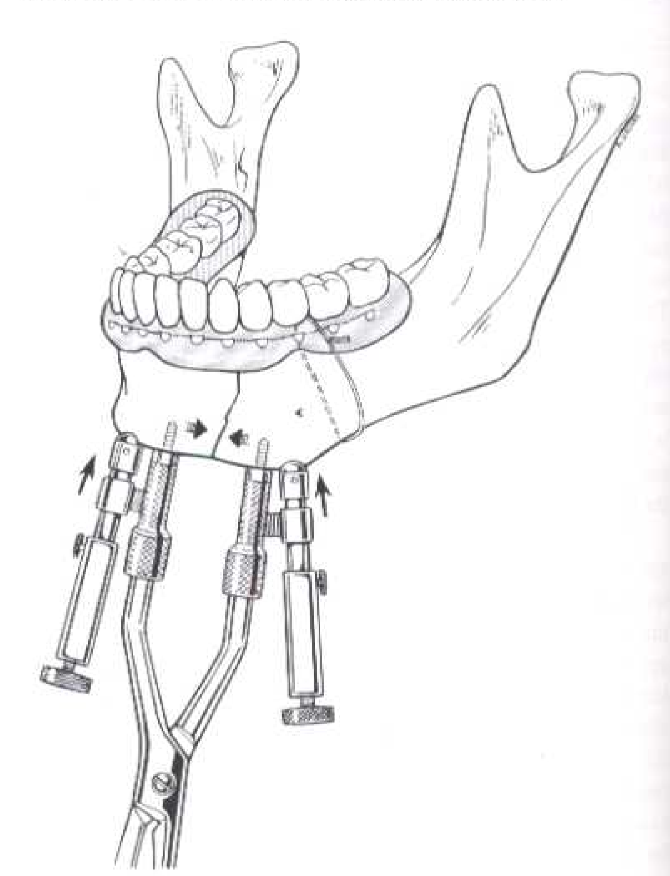


FIG. 5-108

A tension band miniplate is applied by using monocortical screws along the tension line of Champy, using at least a four-hole plate. Because there are no teeth present, this plate can be placed in front of or just above the mental foramen as needed, depending on the shape of the bone. The plate is bent to shape, and screws are placed sequentially, one at a time. (Note that bicortical screws may be used if preferred because there are no tooth roots and the nerve is not at risk in this area. However, if the plate extends below and behind the foramen, then monocortical screws should be used.)

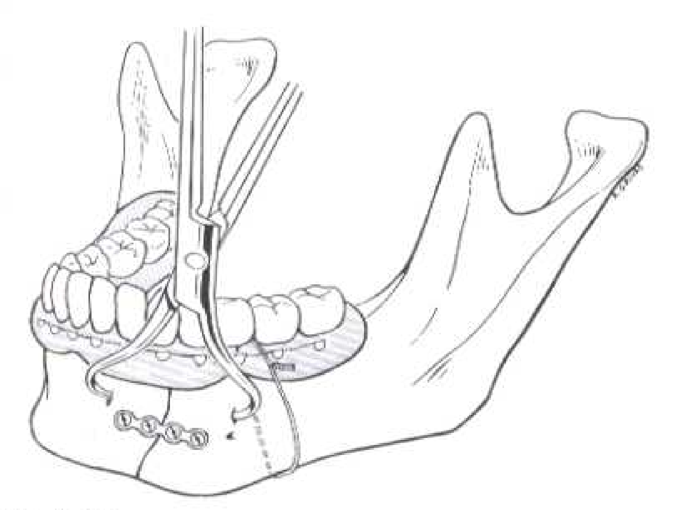


FIG. 5-109

An appropriate compression plate is selected, using at least a four-hole plate. This is fixed along the inferior third of the mandible. Be sure to position the plate well below the inferior alveolar nerve. The plate is held in position with plate-holding forceps after precise bending to the mandibular contour has been successfully completed, usually bending a template first and then bending the plate.

Plate application is completed using two bicortical compression screws eccentrically placed away from the fracture

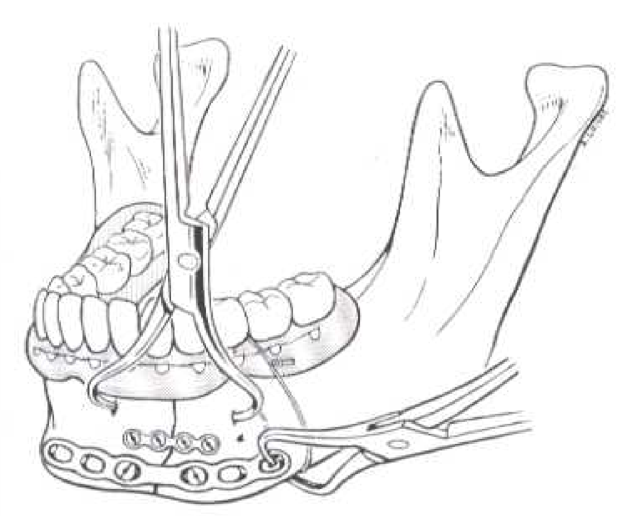


FIG. 5-110

and two to six bicortical neutral screws (obviously depending on the length of the plate). When a mandibular reduction forceps has been used, the locking screw is released after the two compression screws have been placed, and the pliers may be removed completely any time after four screws have been placed.

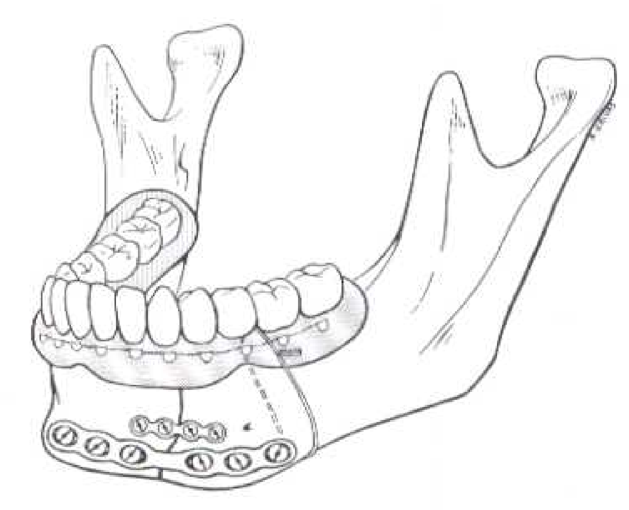


FIG. 5-111

The wound is irrigated, drained, and closed. IMF may now be removed.

MINIPLATE FIXATION

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 71

Occlusion is established using dentures or splints. (Some experienced surgeons perform miniplate fixation in this situation without using splints; however, establishing the occlusal relationship provides a more dependable outcome, particularly when the patient has more than one fracture site.) For miniplate fixation, an intraoral exposure is generally used.

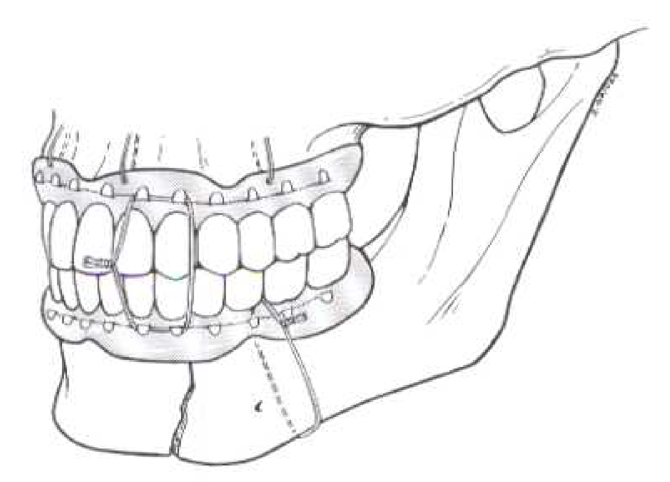


FIG. 5-112

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

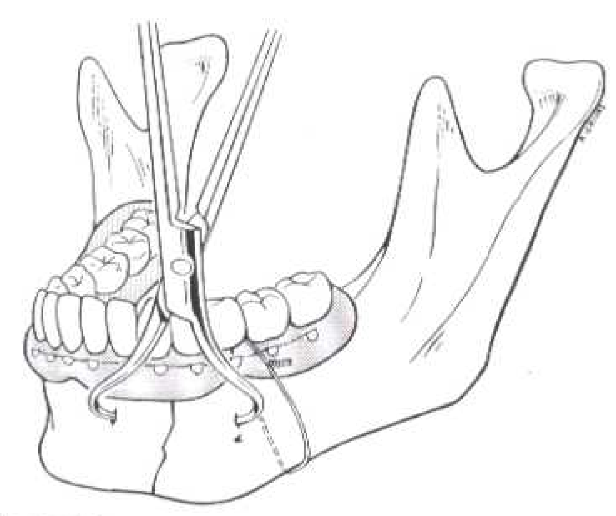


FIG. 5-113

Two miniplates are necessary for stable fixation in the parasymphyseal region. (If there is not enough mandibular height to accommodate two miniplates, then a mandibular reconstruction plate or bone grafting technique is recommended.) The first miniplate is applied by using monocortical screws along the tension line of Champy, using at least a four-hole plate. Because there are no teeth present, this plate can be placed in front of or just above the mental foramen as needed, depending on the shape of the bone. The plate is bent to shape and screws are placed sequentially, one at a time. (Note that bicortical screws may be used if preferred because there are no tooth roots and the nerve is not at risk in this area. However, if the plate extends below and behind the foramen, then monocortical screws should be used.)

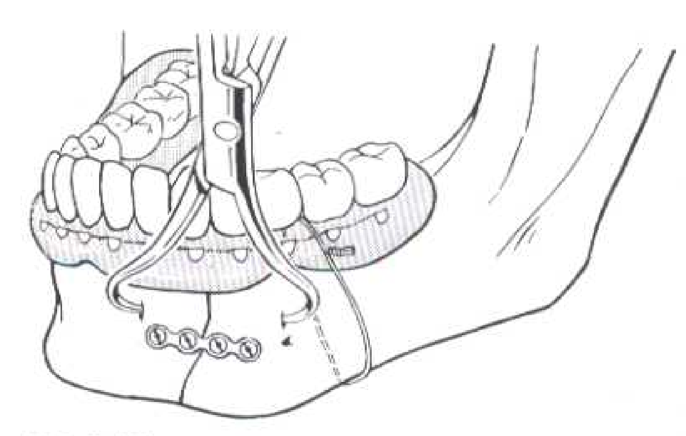


FIG. 5-114

The second miniplate is applied along the inferior ideal osteosynthesis line. This is above the inferior border of the mandible. It is also well below the inferior alveolar nerve; therefore, monocortical or bicortical screws may be used.

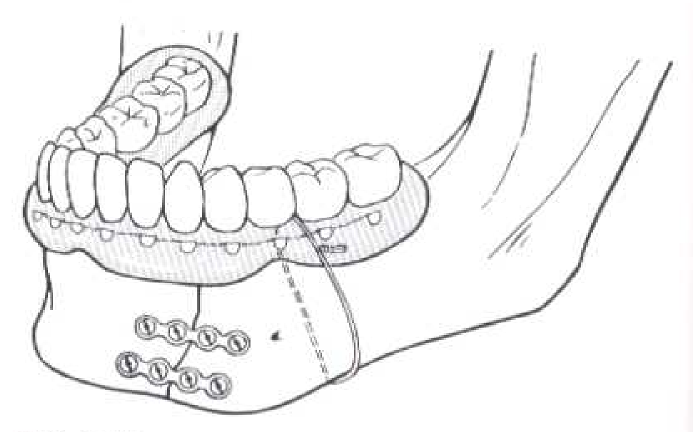


FIG. 5-115

The wound is irrigated, drained, and closed. IMF may now be removed.

THREE-DIMENSIONAL PLATE FIXATION

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 71

NOTE: *It is imperative when using the three-dimensional plate for mandible fracture repair that plates of the proper thickness and size be used. The 1.0-mm thick plate is used with 2.0-mm screws. A three-dimensional microplate should not be used for mandibular repair.*

Occlusion is first established using dentures or splints. (Some experienced surgeons perform miniplate fixation in this situation without using splints; however, establishing the occlusal relationship provides a more dependable outcome, particularly when the patient has more than one fracture site). For three-dimensional plate fixation, an intraoral exposure is generally used.

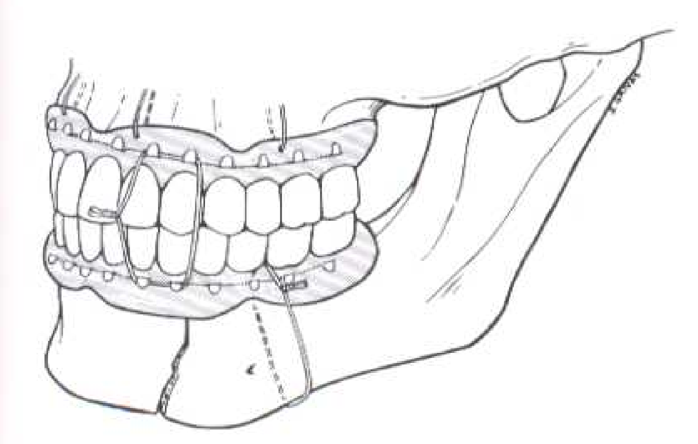


FIG. 5-116

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

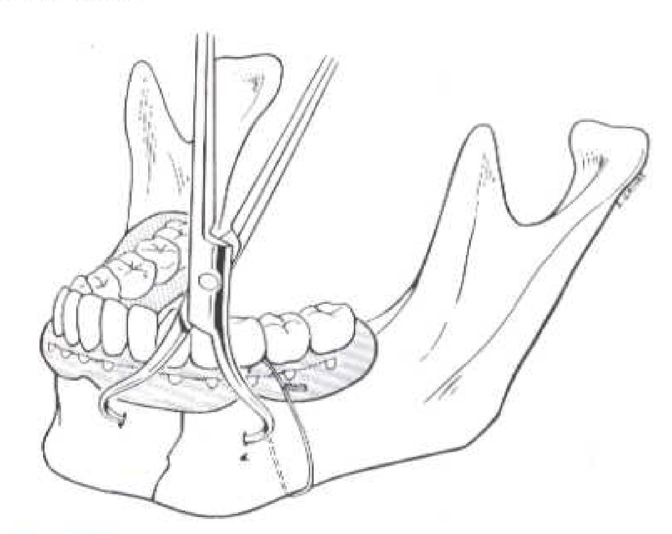


FIG. 5-117

A 2 x 2 (square four-hole) three-dimensional plate is positioned so that the horizontal crossbars are perpendicular to the fracture and the vertical crossbars are parallel to the fracture. The two superior holes are positioned anterior to and/or above the inferior alveolar nerve. Monocortical or bicortical screws may therefore be used. The two inferior screws are now placed. These are anterior to and below the nerve and may therefore also be either monocortical or bicortical. For any reason, if the nerve is believed to be at risk, then monocortical screws should be used.

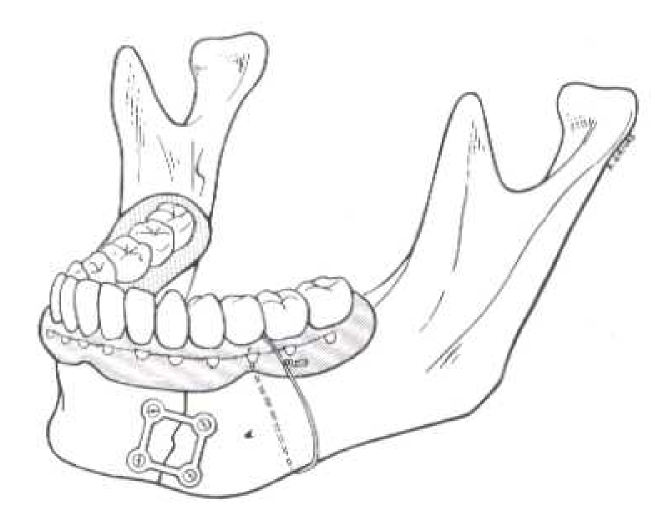


FIG. 5-118

The towel clip is removed, and the wound is irrigated, drained, and closed. IMF may now be removed.

EDCP

Key Principles	pp. 44, 66
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

The occlusal relationship is first established using dentures or splints. The fracture is generally exposed extraorally.

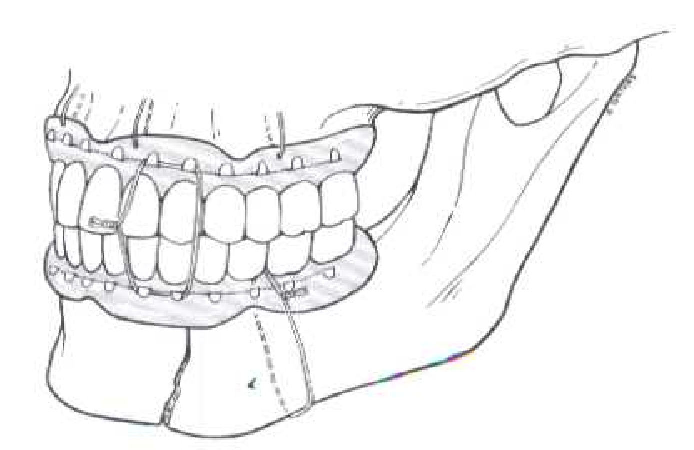


FIG. 5-119

When using an EDCP, the alveolar border (traction side) of the mandible must be precompressed. A modified towel clip may be used, although the mandibular reduction pliers with side rollers for superior precompression is preferred.

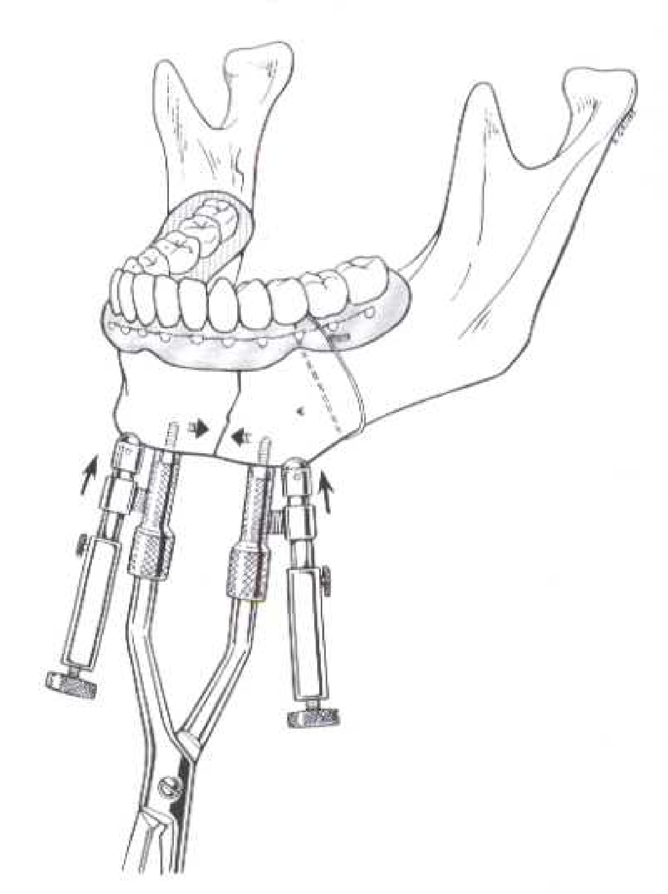


FIG. 5-120

It is recommended that the reduction pliers with side rollers be used to provide prereduction and precompression prior to applying the EDCP. This is fixed to the inferior border of the mandible; it therefore requires an extraoral approach to avoid injury to the inferior alveolar nerve. Horizontal precompression is first applied, the lock nut is tightened, and vertical precompression is then applied with the rollers. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

An appropriate EDCP is selected. Because the EDCP has a top and a bottom, care must be used to make certain that this plate is not applied upside down. **The diagonal holes should point superiorly toward the fracture line!** A template is usually bent to shape first, and the plate is carefully bent to match the template and then, ultimately, the bone. After precise bending to match the mandibular contour has been completed, the plate is positioned and held in place with a plate-holding forceps. First, two horizontal compression screws are placed bicortically, positioning them eccentrically away from the fracture to produce horizontal compression. The locking screw on the reduction pliers is released.

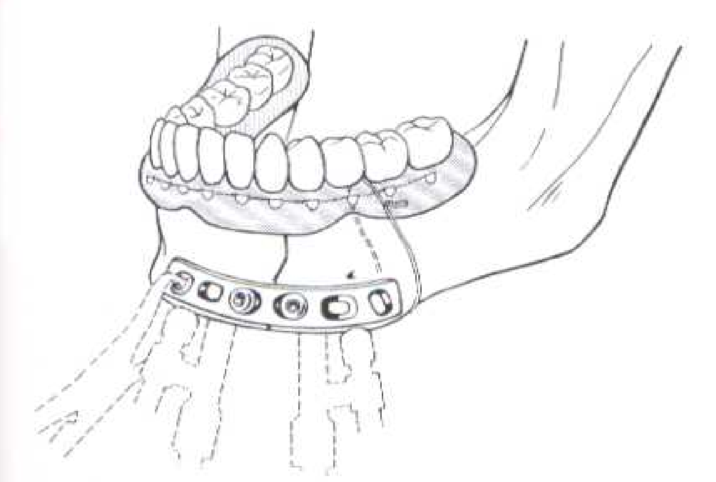


FIG. 5-121

The two superiorly directed compression screws are then placed bicortically, but only after the horizontal compression screws have been fully tightened. These are positioned inferiorly so that compression is directed toward the alveolar border of the fracture. The reduction pliers are then removed.

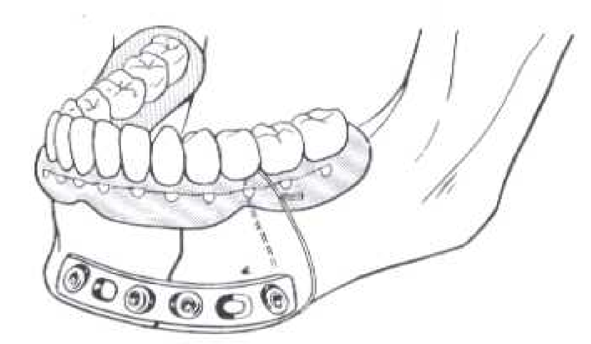


FIG. 5-122

Additional screws (when more than a four-hole plate has been used) are placed neutrally.

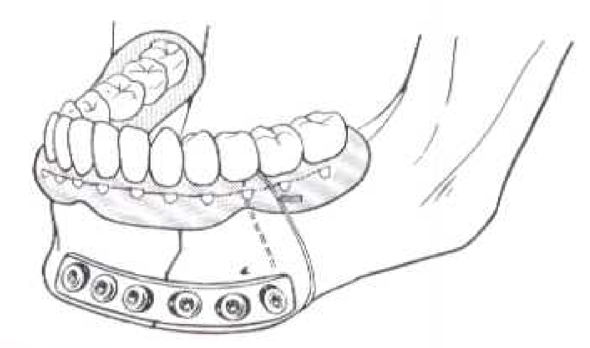


FIG. 5-123

The wound is irrigated, drained, and closed. IMF may now be removed.

MANDIBULAR RECONSTRUCTION PLATE

Key Principles	pp. 46, 68 (61, 62)
Surgical Approaches	
Intraoral	p. 71
Extraoral	p. 81

NOTE: *The mandibular reconstruction plate provides excellent stability, so much so that it can replace defective areas. It is thus excellent for adding stability when the underlying fractured bone is atrophic and weak. A longer plate with numerous fixation points puts the weak area to rest, and it adds to the stability of the repair and, thereby, increases the likelihood of healing.*

Occlusion is first established with dentures or splints when possible. An intraoral or an extraoral approach may be used. In the pencil-thin mandible, the periosteum is left intact to whatever degree is possible to minimize devascularization of bone.

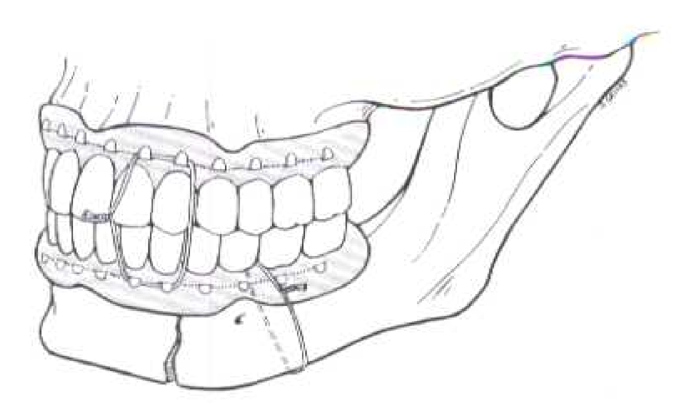


FIG. 5-124

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture.

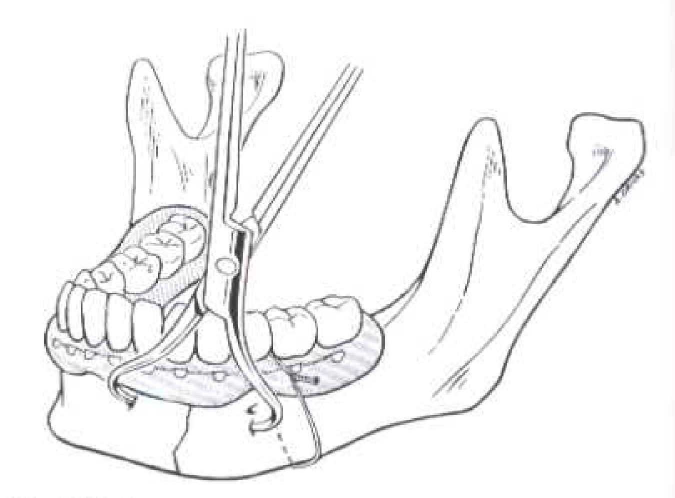


FIG. 5-125

(Optional) A mandibular reduction pliers with side rollers for superior compression may be applied along the inferior border. However, this may not be desirable in the thin atrophic mandible. If they are used, horizontal precompression is applied, the lock screw is tightened, and the rollers are used to compress the superior borders of the fragments. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

A reconstruction plate is selected and applied, taking care to bend it as precisely as possible to the template and to the bone. A plate-holding forceps helps to hold the plate in position for screw placement. At least four or five bicortical screws on each side of the fracture provide excellent support for the weak atrophic bone. This generally requires transbuccal placement of at least some screws if the transoral approach is selected. The central screws may be placed eccentrically away from the fracture for compression if desired, and if mandibular height is only slightly higher than the plate, the remaining screws are placed neutrally.

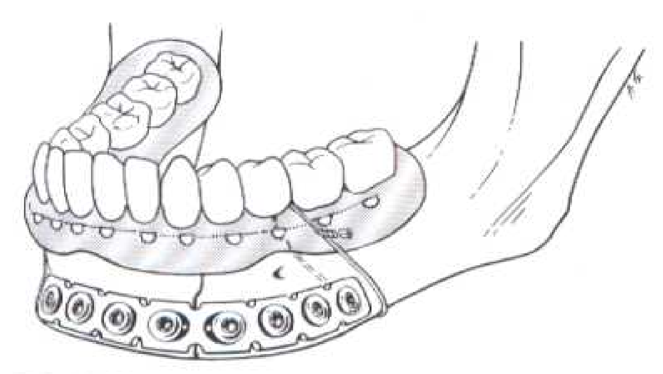


FIG. 5-126

Otherwise, all screws are positioned neutrally.

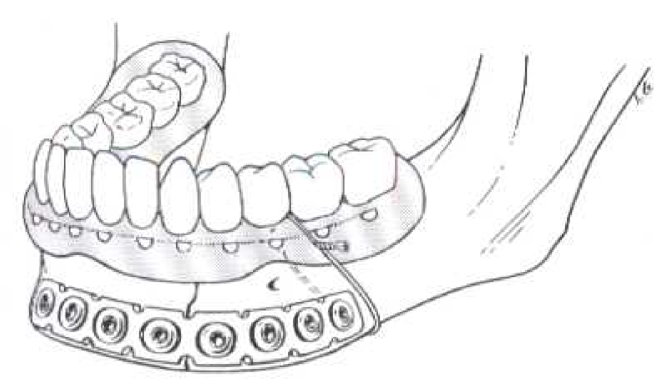


FIG. 5-127

The wound is irrigated, drained, and closed. IMF, if present, may now be removed.

LAG SCREW FIXATION

Key Principles	pp. 47, 50
Surgical Approaches	
Intraoral	p. 71

NOTE: *When using this technique, long screws (38–44 mm) must be available.*

Although lag screws can be used to fix parasymphyseal fractures, this technique is more difficult here compared with the symphysis because there is less cortex to catch with the lag screw. The presence of the inferior alveolar nerve also adds to the technical difficulty.

The technique is the same as that for the symphysis, and the reader is referred to pages 170–171. An example of the final outcome is depicted here.

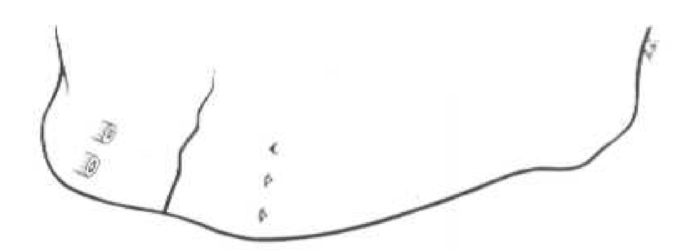


FIG. 5-128

CHAPTER 5

Body: Dentulous (Nonoverlapping)

Rigid fixation of mandibular body fractures is somewhat more technically difficult than symphyseal and parasymphyseal fractures as a result of the somewhat more difficult exposure, both extraorally and intraorally. Extraoral exposure requires significant dissection. Intraoral exposure necessitates working under and behind the mental nerve and the transbuccal placement of at least the more posterior screws.

TENSION BAND ARCH BAR AND COMPRESSION PLATE

Key Principles	pp. 43, 62
Surgical Approaches	
Intraoral	p. 74
Extraoral	p. 83

The tension band arch bar is first applied to the teeth across the fracture site, and proper occlusion is reestablished. The fracture is exposed either intraorally or extraorally.

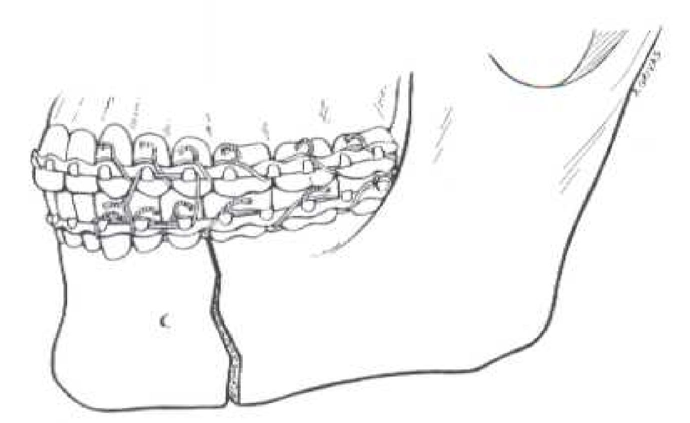


FIG. 5-129

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture. In the body region, an extraoral approach is needed for this to be used.

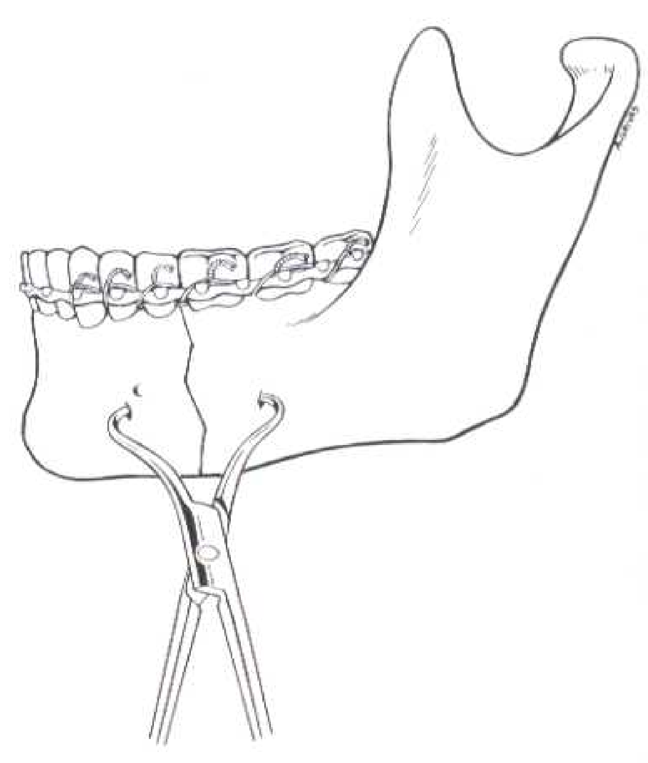


FIG. 5-130

(Optional) A mandibular reduction pliers may be applied along the inferior border of the mandible. This can only be used if an extraoral approach is used. Using these pliers, the fragments are reduced, and horizontal precompression is applied. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

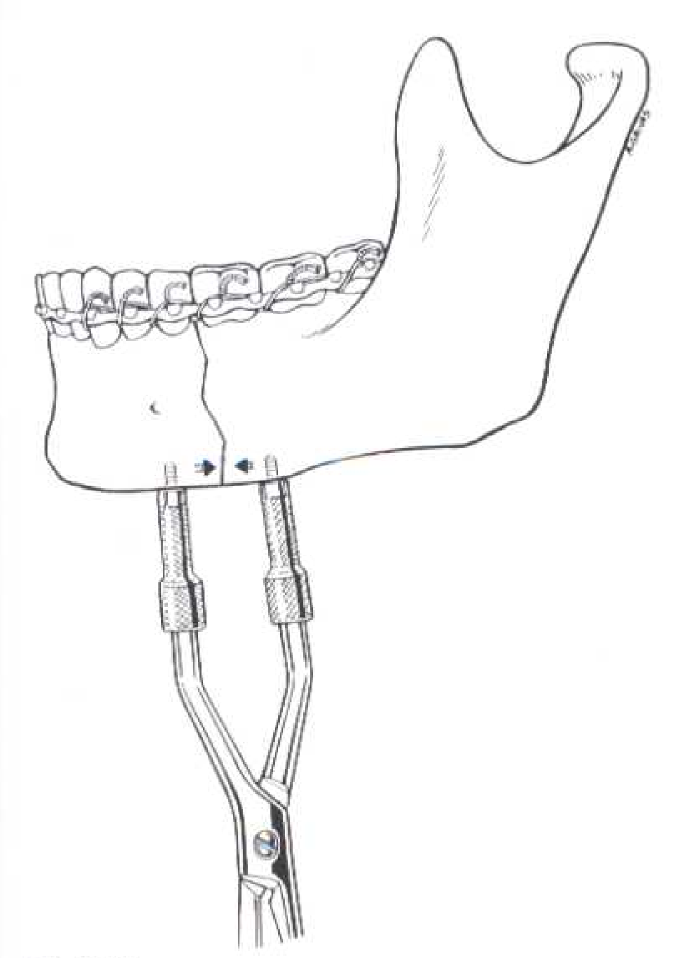


FIG. 5-131

An appropriate compression plate is selected, using at least a four-hole plate, and this is fixed along the inferior third of the mandible. Be sure to position the plate below the inferior alveolar nerve. If an intraoral exposure is used, a transbuccal approach is needed to complete screw placement. The plate is carefully bent to match the mandibular contour, usually bending a template first and then bending the plate. A plate-holding forceps helps hold the plate in position if an extraoral approach has been used. With intraoral placement of a compression plate, care must be taken to ensure placement of the plate at the inferior border.

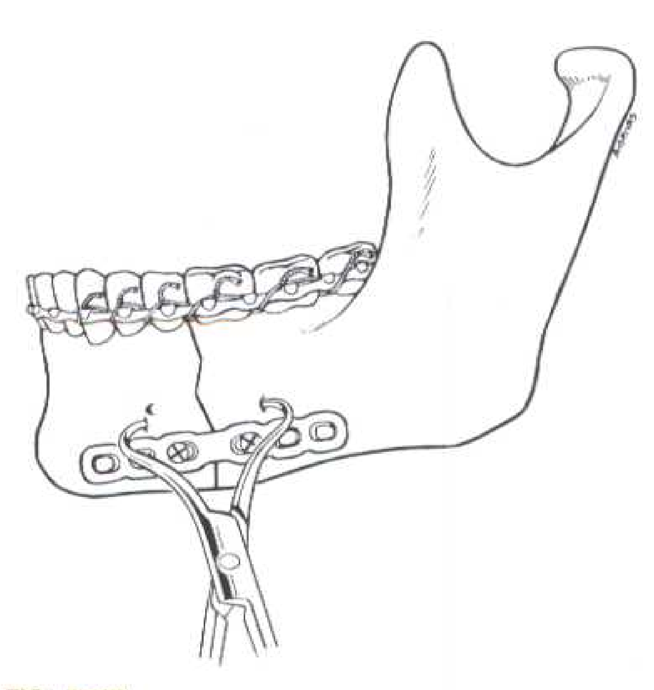


FIG. 5-132

Plate application is completed, using two bicortical compression screws (eccentrically placed away from the fracture) and two to six bicortical neutral screws, depending on the length of the plate. When a mandibular reduction forceps has been used, the locking screw is released after the two compression screws have been placed, and the pliers may be removed completely at any time after four screws have been placed.

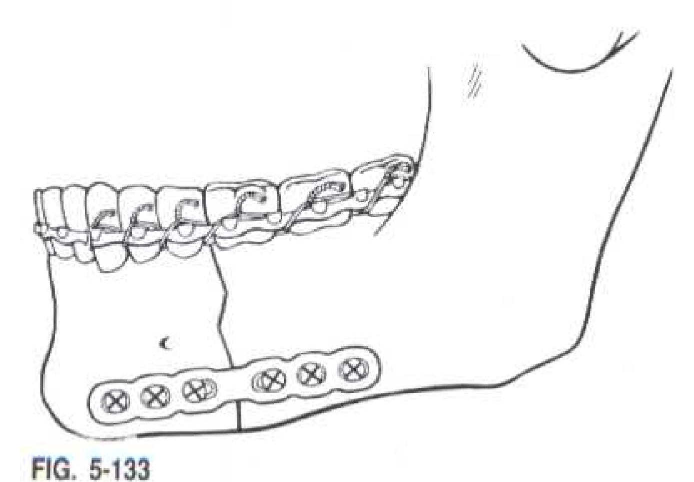


FIG. 5-133

The wound is irrigated, drained, and closed. IMF may now be released.

TENSION BAND PLATE AND COMPRESSION PLATE

Key Principles	pp. 42, 43, 61, 62
Surgical Approaches	
Intraoral	p. 74
Extraoral	p. 83

Occlusion is established, but a tension band arch bar has not been placed or is inadequate as a tension band. The fracture is exposed either intraorally or extraorally.

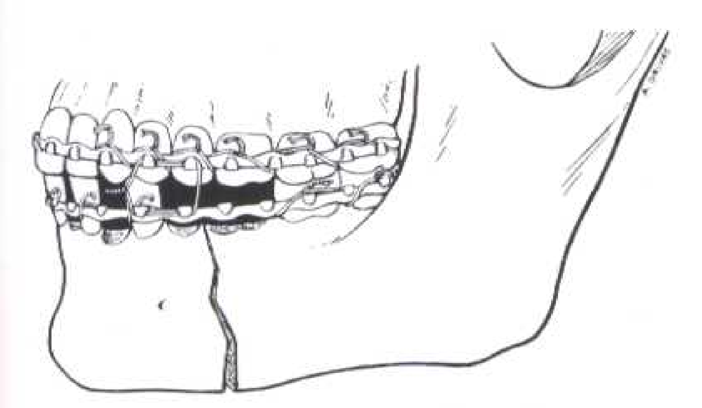


FIG. 5-134

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture. In the body region, an extraoral approach is needed for this to be used.

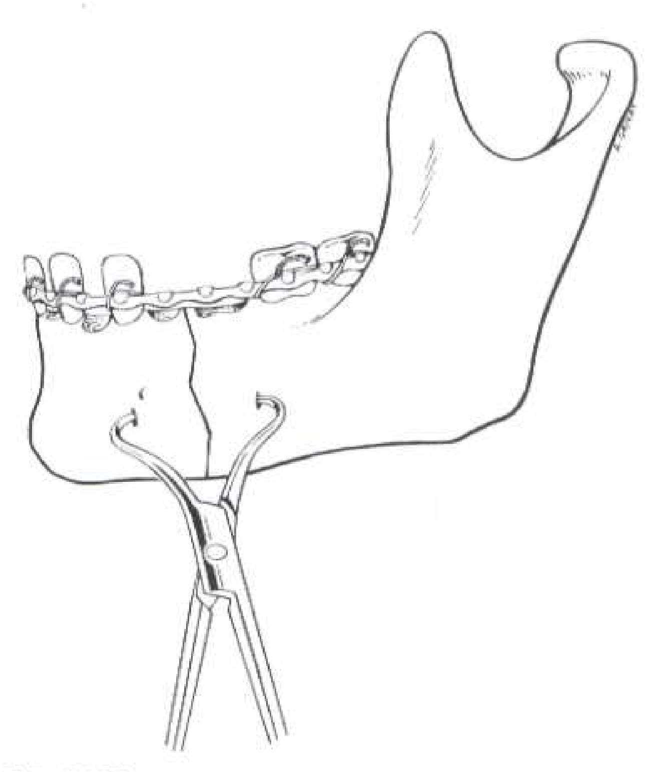


FIG. 5-135

(Optional) A mandibular reduction pliers with side rollers may be fixed to the inferior border of the mandible for reduction and precompression. This requires an extraoral approach. Rollers must be used because the tension band is inadequate; otherwise, the alveolar portion of the fracture will be distracted. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

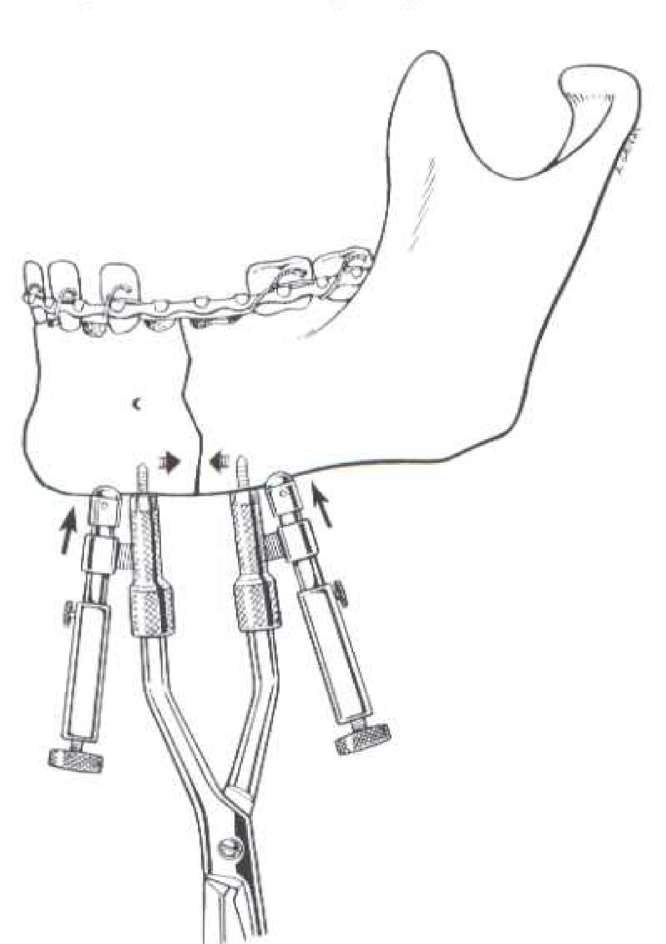


FIG. 5-136

A tension band miniplate is applied along the tension line of Champy, using at least a four-hole plate; this lies between the tooth roots and the inferior alveolar nerve, approximately 1.5 to 2 crown heights below the gingival margin. Monocortical screws are placed sequentially, one at a time.

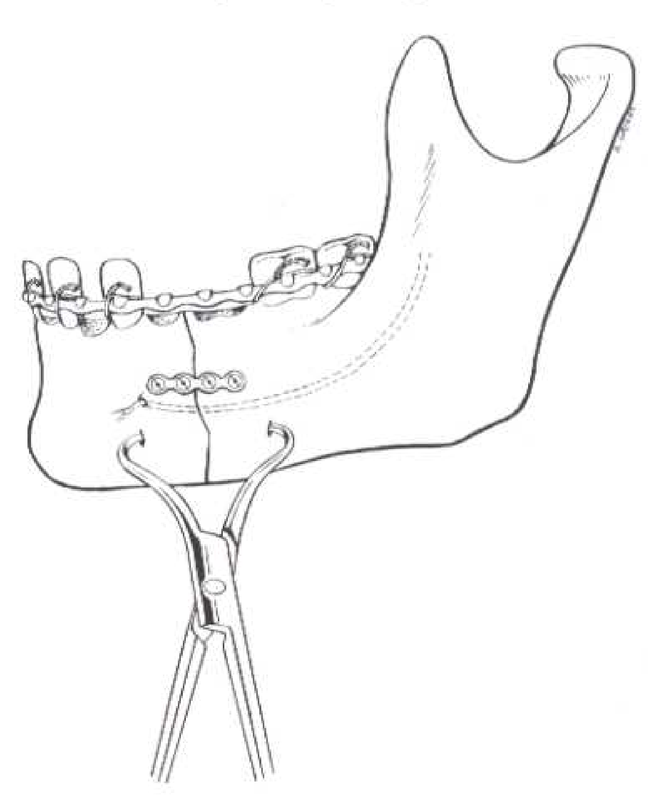


FIG. 5-137

An appropriate compression plate is selected, using at least a four-hole plate, and this is fixed along the inferior third of the mandible. Be sure to position the plate below the inferior alveolar nerve. If an intraoral exposure is used, a transbuccal approach is needed to complete screw placement. The plate is carefully bent to match the mandibular contour, usually bending a template first and then bending the plate. A plate-holding forceps helps hold the plate in position if an extraoral approach has been used. With intraoral placement of a compression plate, care must be taken to ensure placement of the plate at the inferior border.

Plate application is completed, using two bicortical compression screws (eccentrically placed away from the fracture) and two to six neutral screws, depending on the length of the plate. When a mandibular reduction forceps has been used, the locking screw is released after the two compression screws have been placed, and the pliers may be removed completely at any time after four screws have been placed.

The wound is irrigated, drained, and closed. IMF may now be released.

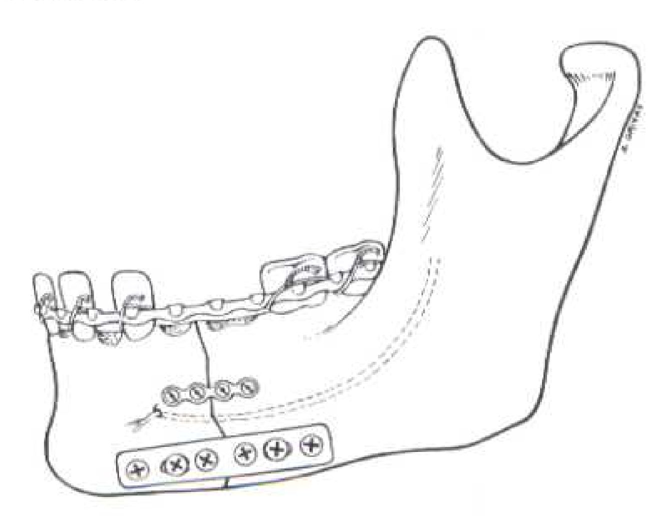


FIG. 5-139

FIG. 5-138

MINIPLATE FIXATION

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 74

Occlusion is established using loops or arch bars for IMF. For miniplate fixation, an intraoral exposure is generally used.

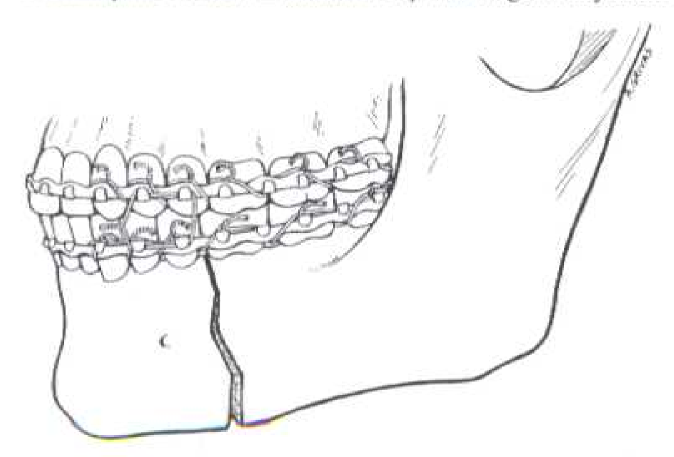


FIG. 5-140

A single miniplate is placed along the ideal osteosynthesis line of tension of Champy, using at least a four-hole plate, although a longer plate is preferable. This is approximately 1.5 to 2 crown heights below the gingival margin. This corresponds to the area between the tooth roots and the inferior alveolar canal. Monocortical screws are used, placing them sequentially, one at a time. Transbuccal application may be necessary.

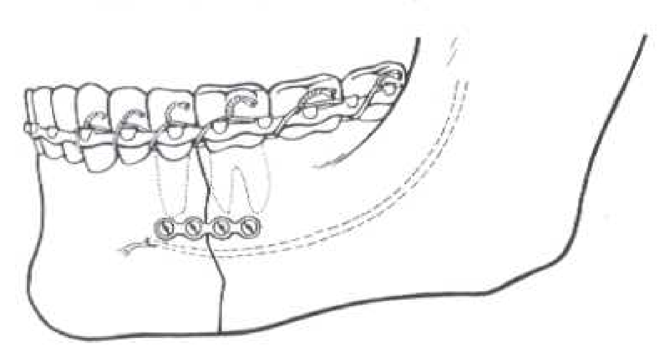


FIG. 5-141

(Optional) A second miniplate may be placed below the first for added stability. This is placed below the inferior alveolar canal.

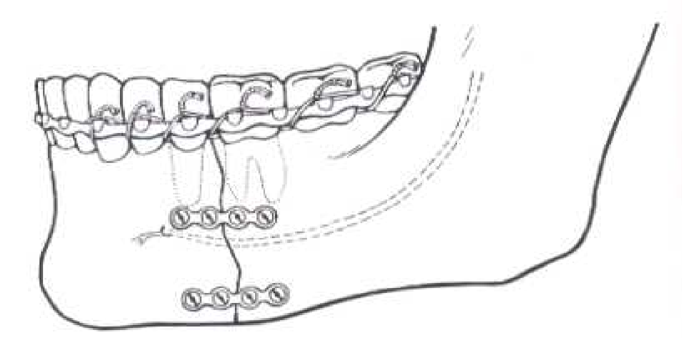


FIG. 5-142

The wound is irrigated, drained, and closed. IMF may now be released.

THREE-DIMENSIONAL PLATE FIXATION

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 74

NOTE: *It is imperative when using the three-dimensional plate for mandible repair that plates of the proper thickness and size be used. The 1.0-mm thick plate is used with 2.0-mm screws. A three-dimensional microplate should not be used for mandibular repair.*

Occlusion is established using loops or arch bars for IMF. For three-dimensional plate fixation, an intraoral exposure is generally used.

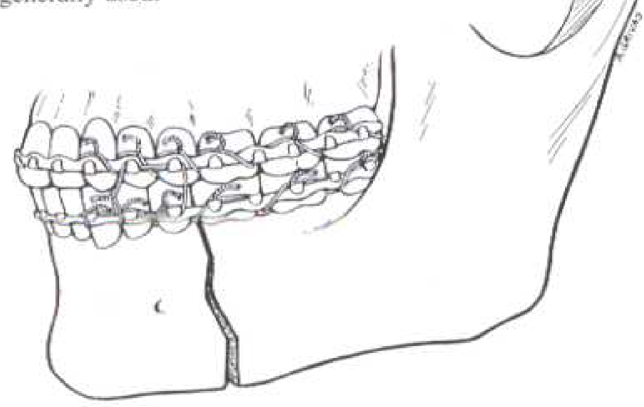


FIG. 5-143

A 2 × 3 (rectangular six-hole) or a 2 × 2 (rectangular or square four-hole) three-dimensional plate is positioned so that the horizontal crossbars are perpendicular to the fracture and the vertical crossbars are parallel to the fracture.

(Option 1) This is positioned above the inferior alveolar nerve canal. Because the upper screws overlie the tooth roots, care must be used to ensure that only the buccal cortex is penetrated when drilling, and 3-mm length screws are placed in the upper holes to avoid tooth root injury. Of course, monocortical screws are also placed in the lower holes.

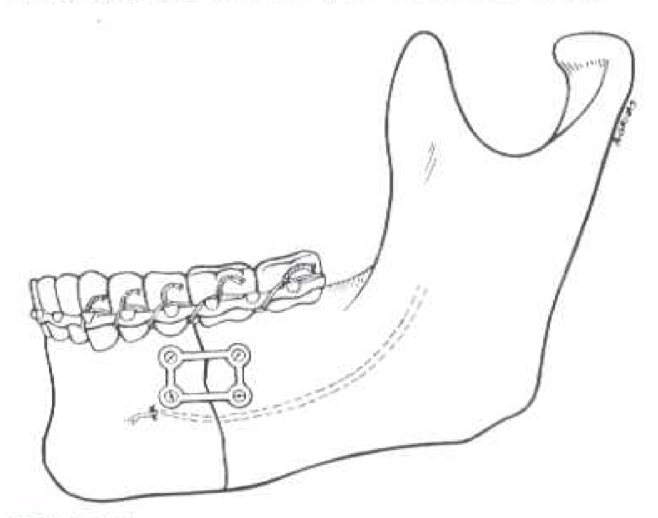


FIG. 5-144

(Option 2) As an alternative, the plate may be placed so that the upper screws are above the nerve canal and the lower screws are below it. Monocortical screws are placed in the two superior holes. Make certain that the most superior screw is at least 5 mm below the tooth roots. This should be between the tooth roots and the inferior alveolar nerve. The two inferior screws are placed below the inferior alveolar canal, again using monocortical screws.

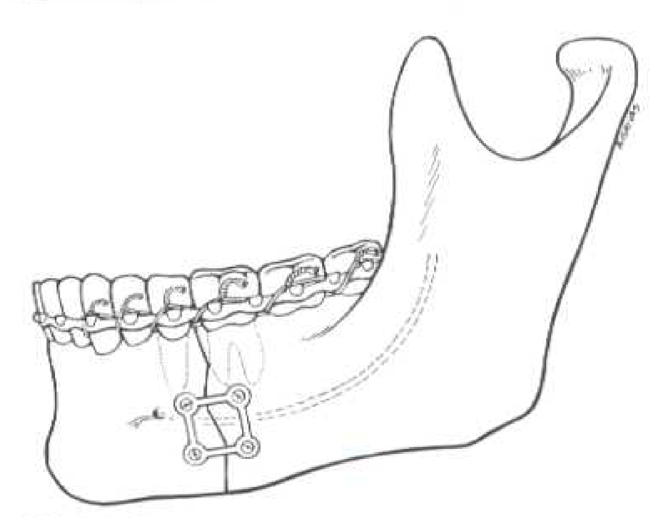


FIG. 5-145

The wound is irrigated, drained, and closed. IMF may now be released.

EDCP

Key Principles	pp. 44, 66
Surgical Approaches	
Intraoral	p. 74
Extraoral	p. 83

NOTE: *This is not the preferred or recommended technique by the authors for this situation. The authors believe that, when it is possible, a tension band technique is preferred if a compression plate is to be used.*

Occlusion is established, but a tension band arch bar has not been placed or is inadequate. The fracture is generally exposed extraorally.

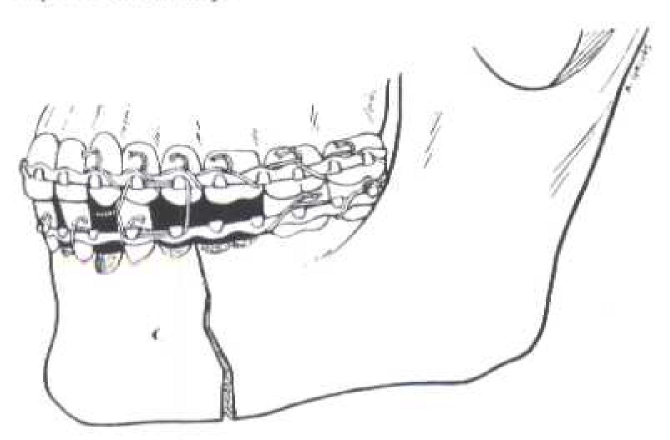


FIG. 5-146

When using an EDCP, the alveolar border (traction side) of the mandible must be precompressed. A modified towel clip may be used, although the mandibular reduction pliers with side rollers for superior precompression is recommended. This is fixed to the inferior border of the mandible. Horizontal precompression is first applied, followed by vertical precompression with the rollers. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

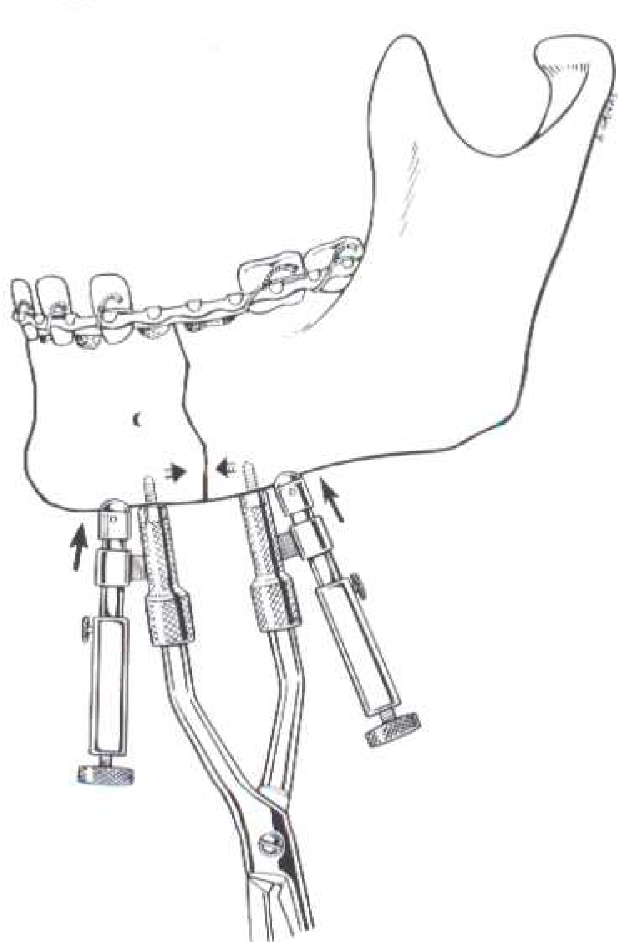


FIG. 5-147

An appropriate EDCP is selected. Because the EDCP has a top and a bottom, care must be used to make certain that this plate is not applied upside down. **The diagonal holes should point superiorly toward the fracture line!** A template is usually bent to shape first, and the plate is carefully bent to match the template and then, ultimately, the bone. After precise bending to match the mandibular contour has been completed, the plate is positioned and held in place with a plate-holding forceps. First, two horizontal compression screws are placed bicortically, positioning them eccentrically away from the fracture to produce horizontal compression. The locking screw on the reduction pliers is released.

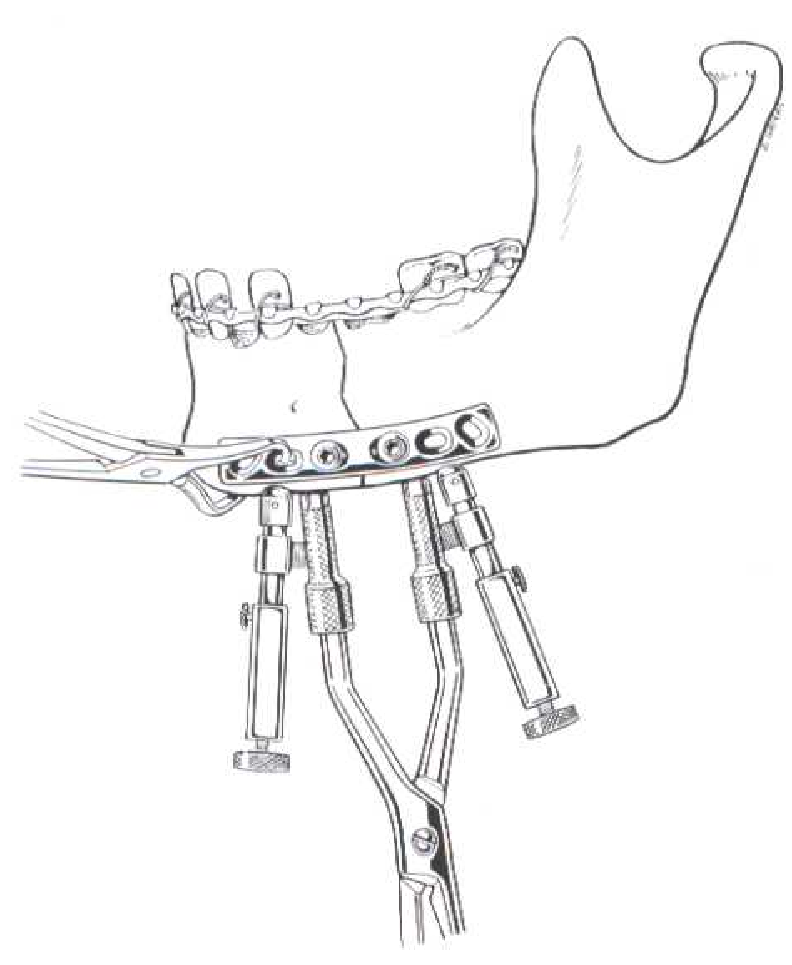


FIG. 5-148

The two superiorly directed compression screws are then placed bicortically, but only after the horizontal compression screws have been fully tightened. These are positioned inferiorly so that compression is directed toward the alveolar border of the fracture. The reduction pliers are then removed.

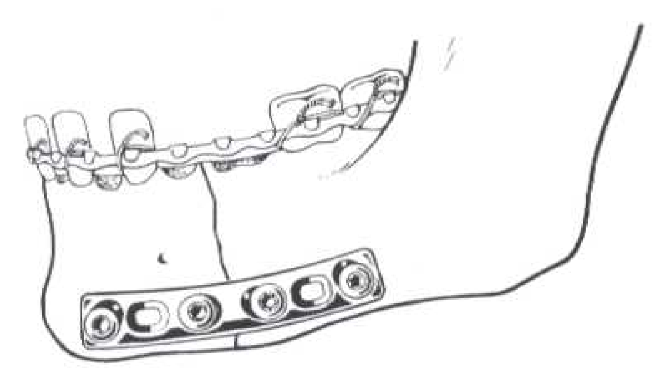


FIG. 5-149

Additional screws (when more than a four-hole plate has been used) are placed neutrally.

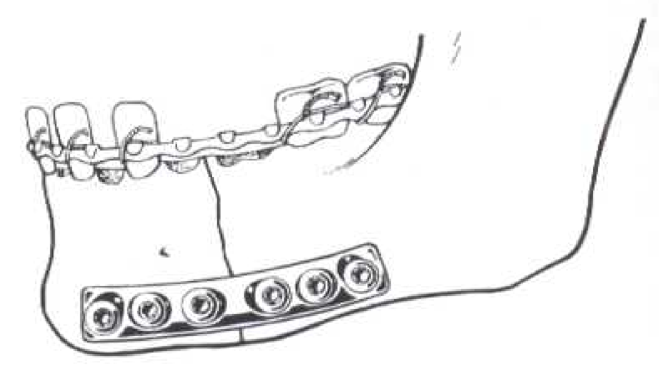


FIG. 5-150

The wound is irrigated, drained, and closed. IMF may now be released.

MANDIBULAR RECONSTRUCTION PLATE

Key Principles	pp. 46, 68 (61, 62)
Surgical Approaches	
Intraoral	p. 74
Extraoral	p. 83

NOTE: *Although the mandibular reconstruction plate provides adequate stability in the absence of a tension band, a tension band is still helpful in making certain that the reduction is properly maintained during repair. The authors therefore recommend that a tension band arch bar be placed when possible. When this is not possible or is inadequate, a tension band miniplate may be applied.*

Occlusion is first established by using a tension band arch bar or loops. The fracture is exposed either intraorally or extraorally, although an extraoral exposure makes bending and application technically easier.

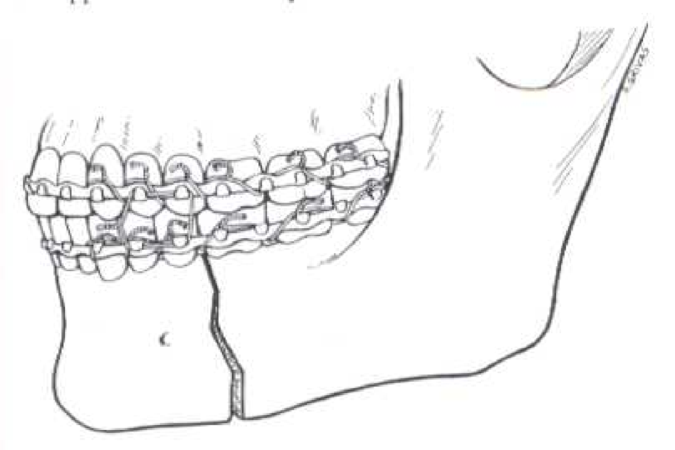


FIG. 5-151

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture. In the body region, an extraoral approach is needed for this to be used.

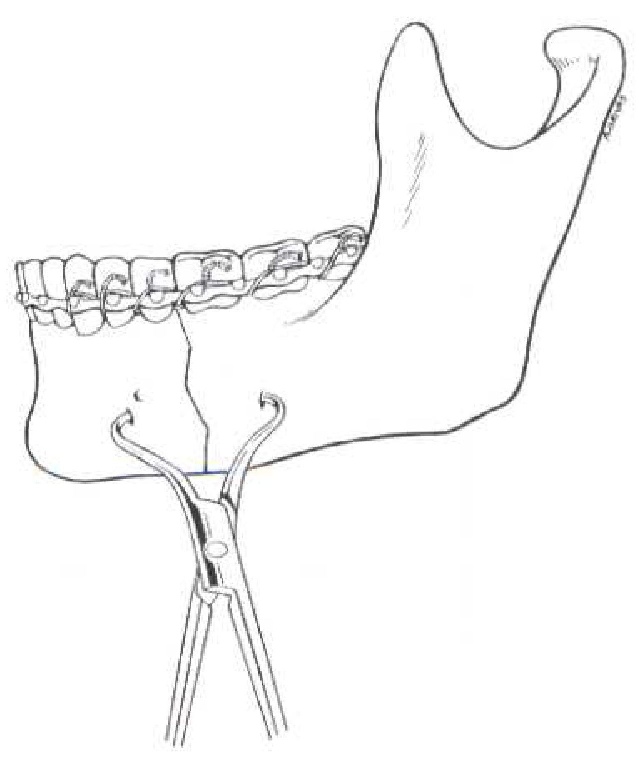


FIG. 5-152

(Optional) A mandibular compression pliers may be applied along the inferior border. No rollers are necessary if a tension band arch bar has been applied; however, if there is no tension band, then rollers must be used. Using the reduction forceps, horizontal precompression is applied. Care should be used to place the screws that hold the forceps to the mandible between the anticipated plate holes to avoid interference with plate application. This can only be done if an extraoral approach is used.

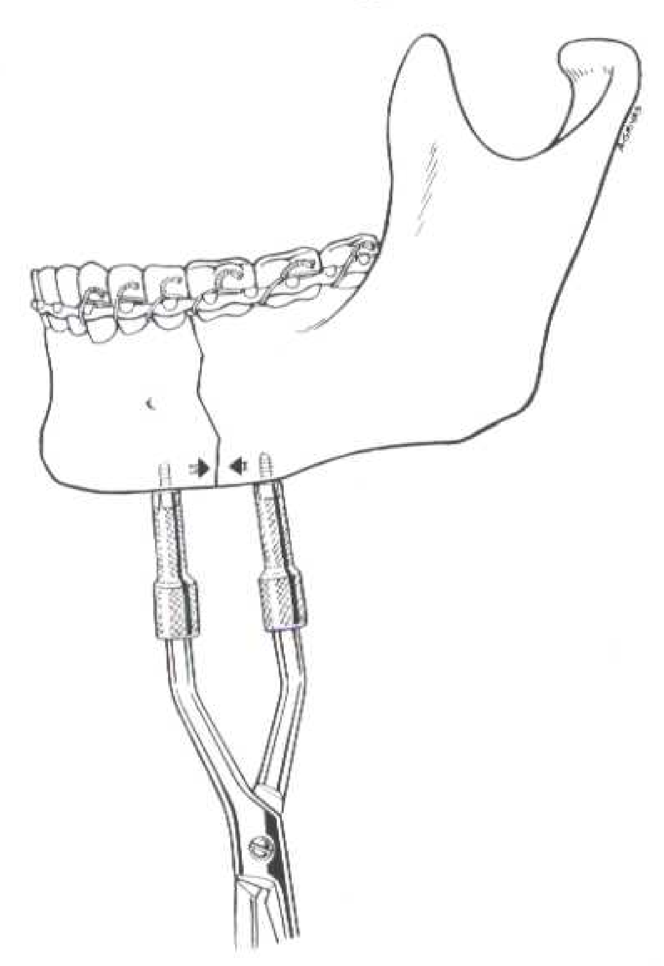


FIG. 5-153

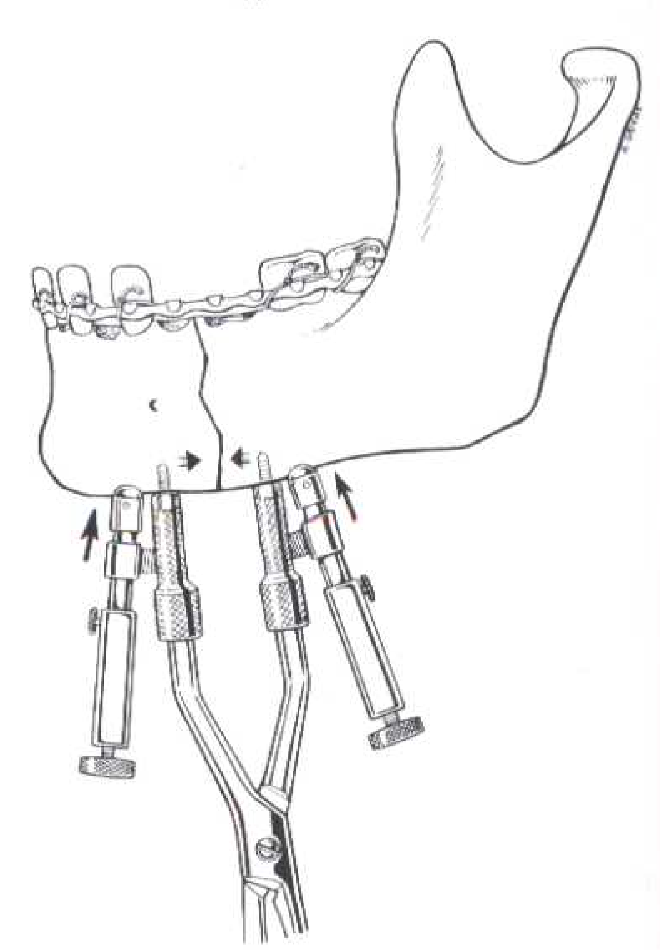


FIG. 5-154

(Optional) If no arch bar has been applied, a four-hole miniplate may be applied as a tension band along the ideal osteosynthesis line of tension of Champy. This is approximately 1.5 to 2 crown heights below the gingival margin. This corresponds to the area between the tooth roots and the inferior alveolar canal. Monocortical screws are placed sequentially, one at a time.

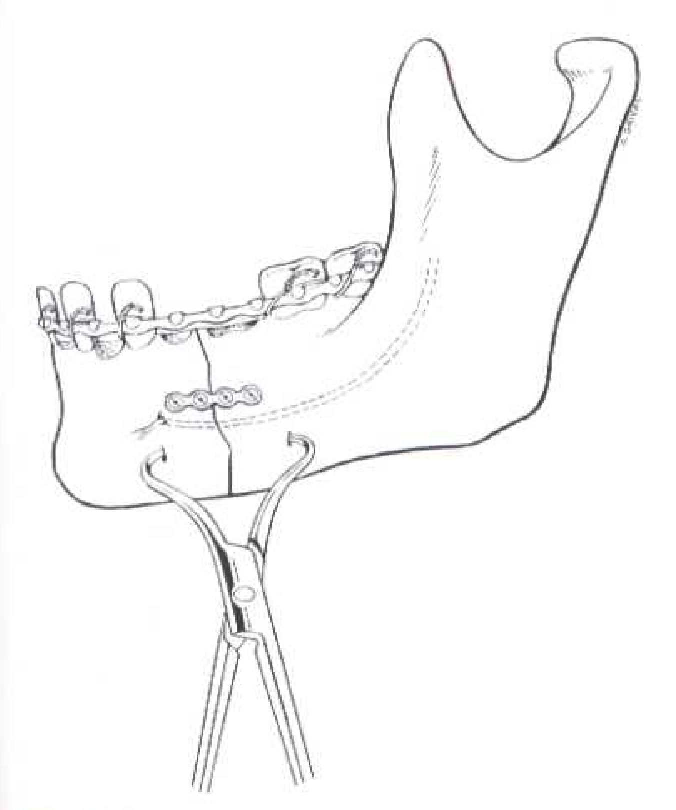


FIG. 5-155

A mandibular reconstruction plate with at least six holes is selected. A template is bent to match the mandibular contour, and the plate is carefully bent to match the template and, ultimately, the mandibular contour of the inferior mandibular border. Bicortical screws are used. If a tension band has been placed, the first two screws can be placed eccentrically away from the site of the fracture to produce compression. The remaining screws are then placed neutrally.

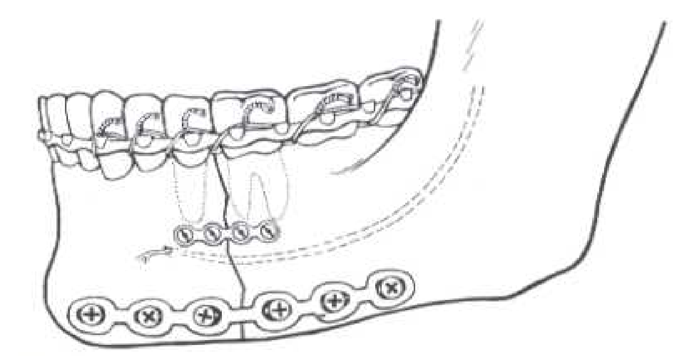


FIG. 5-156

When there is no tension band present, all screws are placed neutrally, placing at least three screws on each side of the fracture, although four or five on each side provide greater stability.

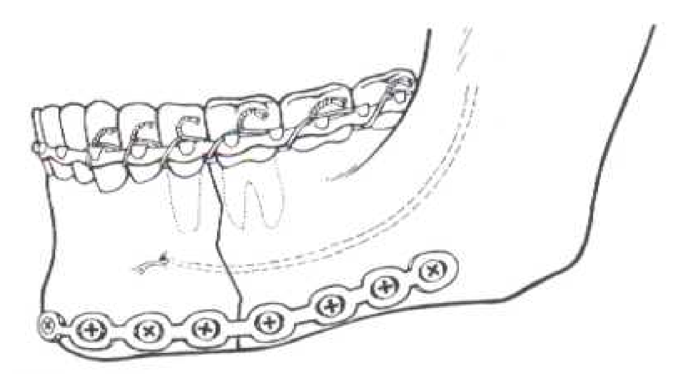


FIG. 5-157

The wound is irrigated, drained, and closed. IMF may now be released.

CHAPTER 6

Body: Edentulous (Nonoverlapping)

The absence of teeth does not negate the importance of establishing the proper relationship of the mandible and maxilla for function. If the patient has dentures, it is preferable to use these as the best guide to the patient's functional occlusion and, therefore, the proper position of the bone fragments. These can be modified to include arch bars to allow for the easy creation of the proper occlusal relationship. If the patient does not have dentures, it is recommended that the occlusal relationship be established with splints. If the bone is very atrophic, we recommend the use of a mandibular reconstruction plate or a bone grafting technique to increase the likelihood of achieving stability and, therefore, bony union.

Rigid fixation of mandibular body fractures is somewhat more technically difficult than symphyseal and parasymphyseal fractures because of the somewhat more difficult exposure, both extraorally and intraorally. Extraoral exposure requires significant dissection. Intraoral exposure necessitates working under and behind the mental nerve and the transbuccal placement of at least the more posterior screws.

MINIPLATE AND COMPRESSION PLATE

Key Principles	pp. 42, 43, 61, 62
Surgical Approaches	
Intraoral	p. 74
Extraoral	p. 83

Occlusion is first established with dentures or splints. The fracture is exposed either intraorally or extraorally.

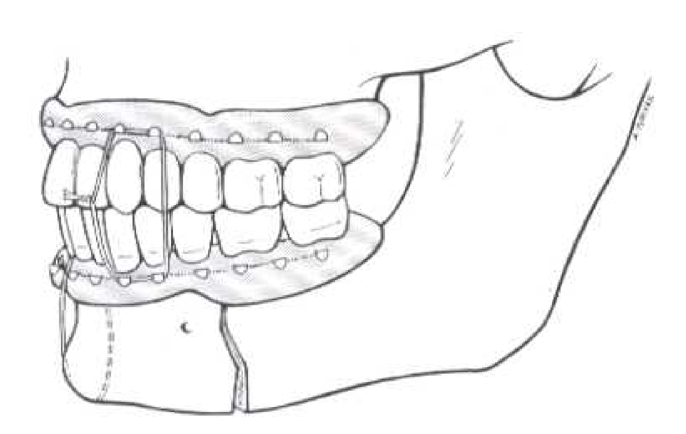


FIG. 5-158

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture. In the body region, an extraoral approach is needed for this to be used.

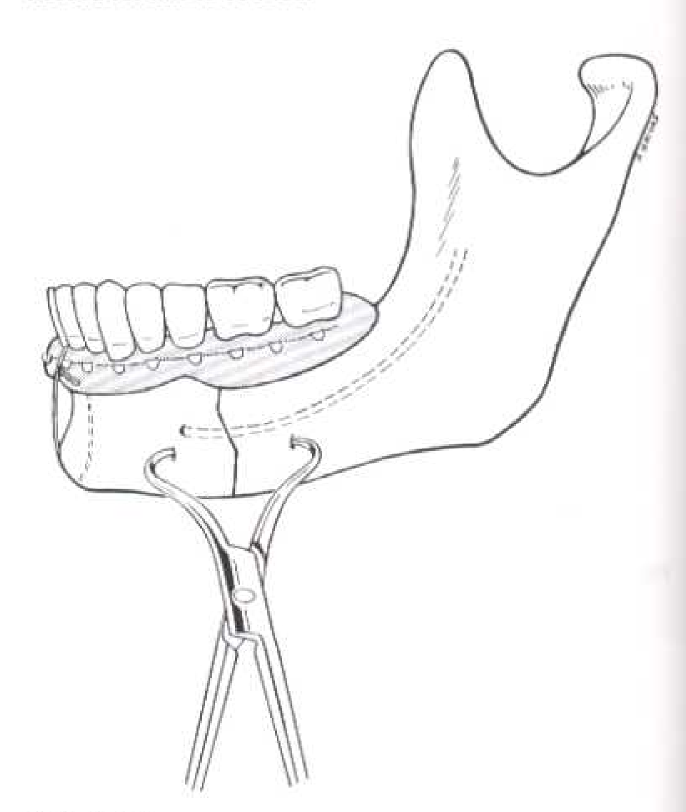


FIG. 5-159

(Optional) A mandibular compression pliers with side rollers for superior compression may be applied along the inferior border. This can only be used if an extraoral approach is used. This is fixed to the inferior mandible. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application. Using these pliers, horizontal precompression is first applied, and the lock nut is tightened. The rollers are then used to compress the superior borders of the fragments together.

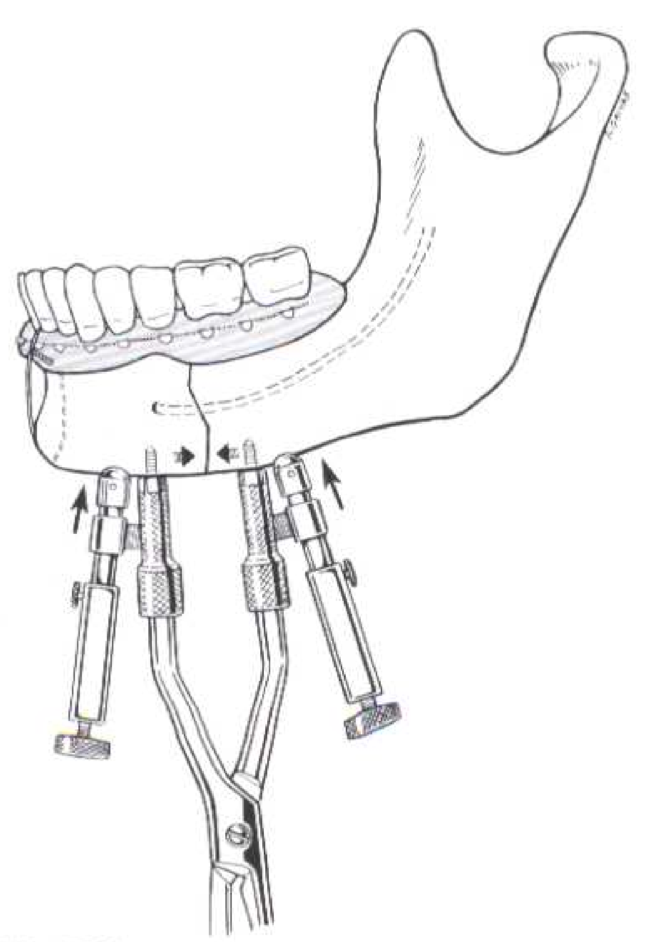


FIG. 5-160

A tension band miniplate is applied along the tension line of Champy by using at least a four-hole plate. This lies above the inferior alveolar canal. (There must be enough bone present to accommodate a miniplate; otherwise a reconstruction plate or bone grafting technique should be used.) Monocortical screws are placed sequentially, one at a time.

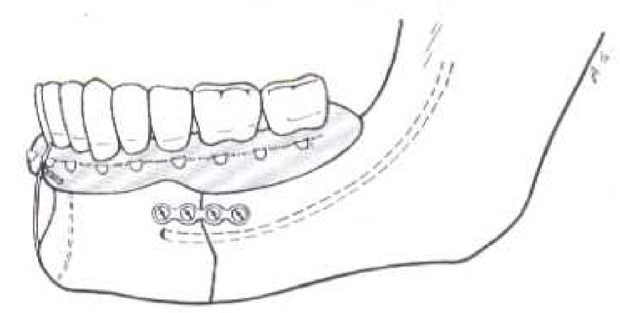


FIG. 5-161

An appropriate compression plate is selected, using at least a four-hole plate, and this is fixed along the inferior third of the mandible. Be sure to position the plate below the inferior alveolar nerve. If an intraoral exposure is used, a transbuccal approach is needed to complete screw placement. The plate is carefully bent to match the mandibular contour, usually bending a template first and then bending the plate. A plate-holding forceps helps hold the plate in position if an extraoral approach has been used. With intraoral placement of a compression plate, care must be taken to ensure placement of the plate at the inferior border.

Plate application is completed, using two compression screws (eccentrically placed away from the fracture)

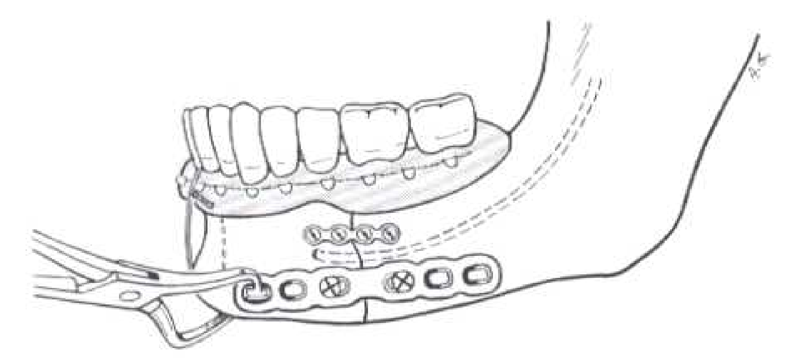


FIG. 5-162

and two to six neutral screws, depending on the length of the plate. When a mandibular reduction forceps has been used, the locking screw is released after the two compression screws have been placed, and the pliers may be removed completely at any time after four screws have been placed.

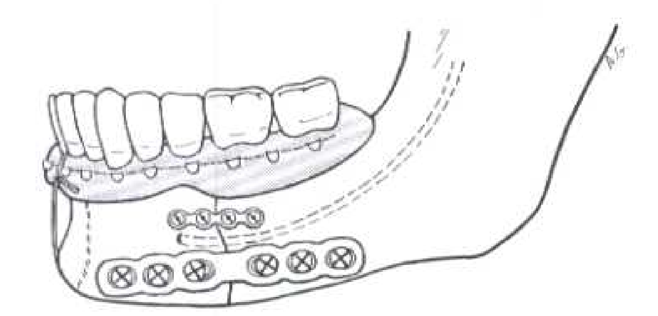


FIG. 5-163

The wound is irrigated, drained, and closed. IMF may now be removed.

MINIPLATE FIXATION

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 74

Occlusion is established using dentures or splints. (Some experienced surgeons perform miniplate fixation in this situation without using splints; however, establishing the occlusal relationship provides a more dependable outcome, particularly when the patient has more than one fracture site.) For miniplate fixation, an intraoral exposure is generally used.

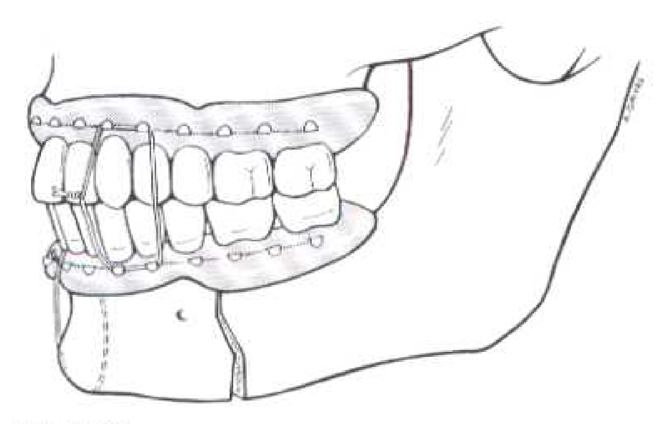


FIG. 5-164

Two miniplates are recommended for stable fixation of the edentulous mandibular body. Therefore, there must be enough bone above the inferior alveolar canal to accommodate a miniplate. (If there is not enough mandibular height to accommodate two miniplates, then a mandibular reconstruction plate or bone grafting technique is recommended.) The first miniplate is placed along the tension line of Champy, above the nerve canal, using at least a four-hole plate. Monocortical screws are placed sequentially, one at a time.

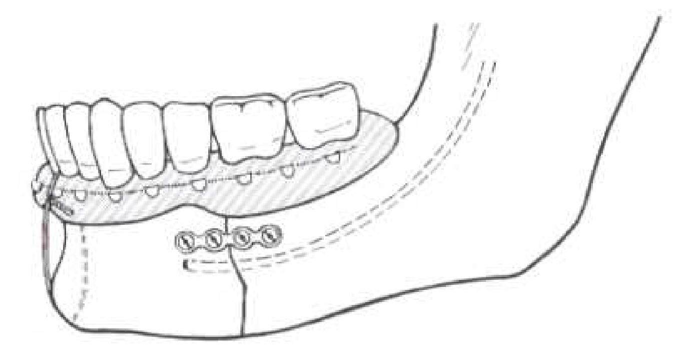


FIG. 5-165

A second miniplate is placed below the first for added stability. This is placed below the inferior alveolar canal. Monocortical or bicortical screws may be used in this area.

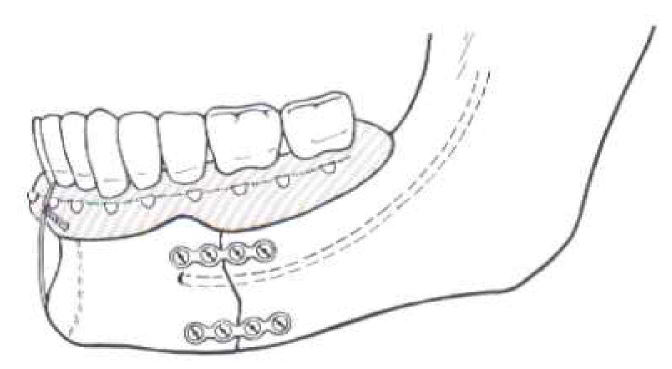


FIG. 5-166

The wound is irrigated, drained, and closed. IMF may now be removed.

THREE-DIMENSIONAL PLATE FIXATION

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 74

Note: It is imperative when using the 3-D plate for mandible fracture repair that plates of the proper thickness and size be used. The 1.0 mm thick plate is used with 2.0 mm screws. A *micro 3-D plate should not be used for mandibular repair.*

Occlusion is first established using dentures or splints. (Some experienced surgeons perform miniplate fixation in this situation without using splints; however, establishing the occlusal relationship provides a more dependable outcome, particularly when the patient has more than one fracture site). For three-dimensional plate fixation, an intraoral exposure is generally used.

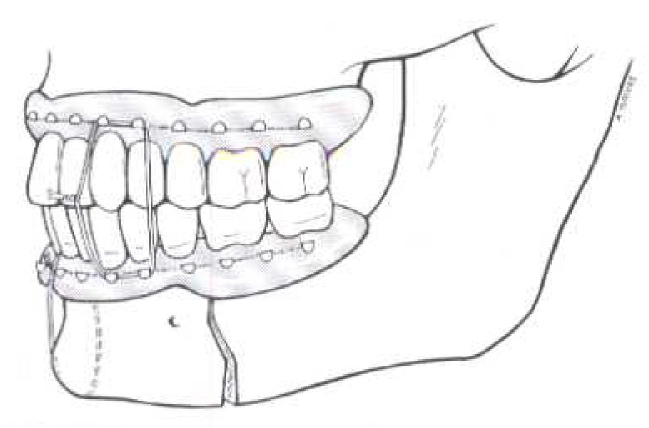


FIG. 5-167

A 2 × 2 (square four-hole) three-dimensional plate is positioned so that the horizontal crossbars are perpendicular to the fracture and the vertical crossbars are parallel to the fracture. There must be enough bone above the inferior alveolar canal to accommodate the upper screws. (If there is not enough mandibular height for these, then a mandibular reconstruction plate or bone grafting technique is recommended.) The two superior screws are placed above the nerve canal using monocortical screws. The two inferior screws are now placed. These are below the nerve and may therefore be either monocortical or bicortical. For any reason, if the nerve is believed to be at risk, then monocortical screws should be used.

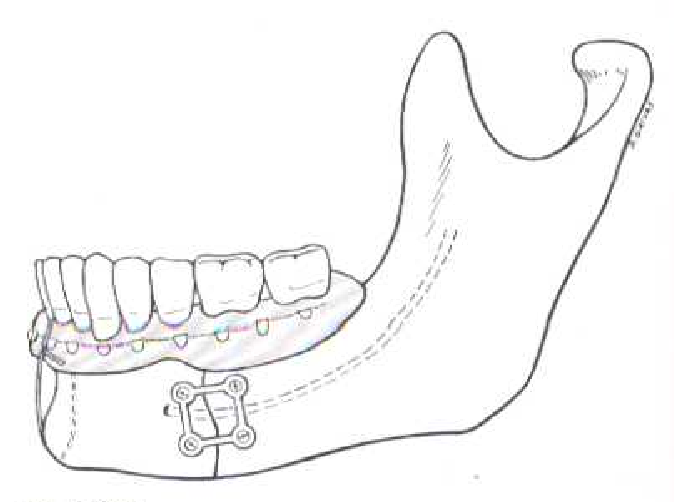


FIG. 5-168

The wound is irrigated, drained, and closed. IMF may now be removed.

EDCP

Key Principles	pp. 44, 66
Surgical Approaches	
Intraoral	p. 74
Extraoral	p. 83

The occlusal relationship is first established using dentures or splints. The fracture is generally exposed extraorally.

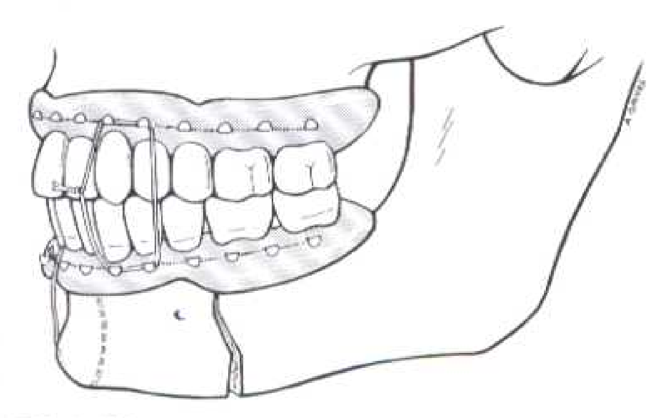


FIG. 5-169

When using an EDCP, the alveolar border (traction side) of the mandible must be precompressed. A modified towel clip may be used, although the reduction pliers with side rollers for superior precompression is recommended. This is fixed to the inferior border of the mandible; it therefore requires an extraoral approach. Horizontal precompression is first applied, the lock nut is tightened, and vertical precompression is then applied with the rollers. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

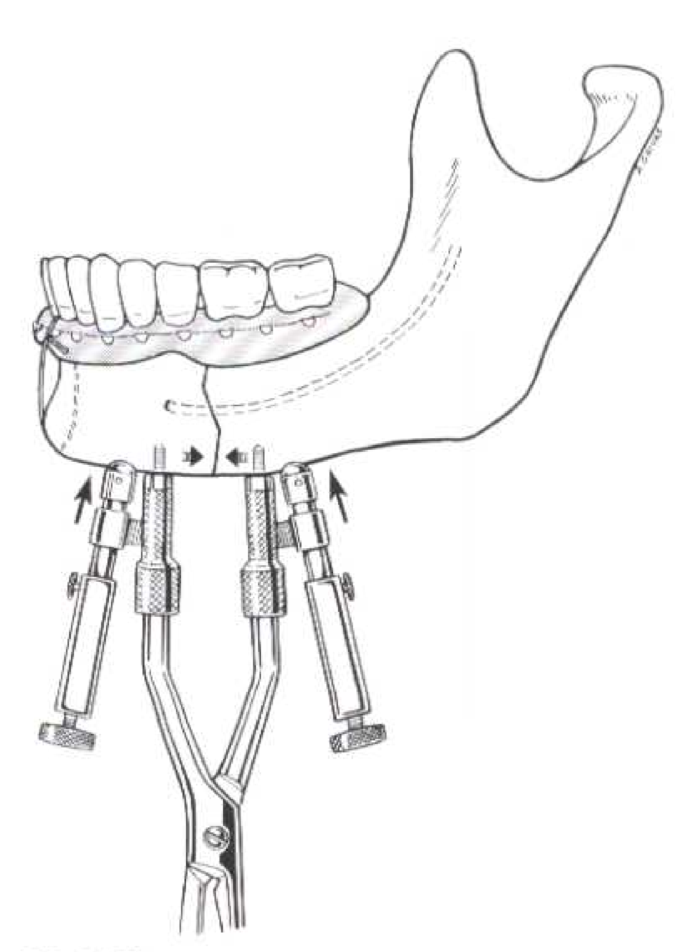


FIG. 5-170

An appropriate EDCP is selected. Because the EDCP has a top and a bottom, care must be used to make certain that this plate is not applied upside down. **The diagonal holes should point superiorly toward the fracture line!** A template is usually bent to shape first, and the plate is carefully bent to match the template and then, ultimately, the bone. After precise bending to match the mandibular contour has been completed, the plate is positioned and held in place with a plate-holding forceps. First, two horizontal compression screws are placed bicortically, positioning them eccentrically away from the fracture to produce horizontal compression. The locking screw on the reduction pliers is released.

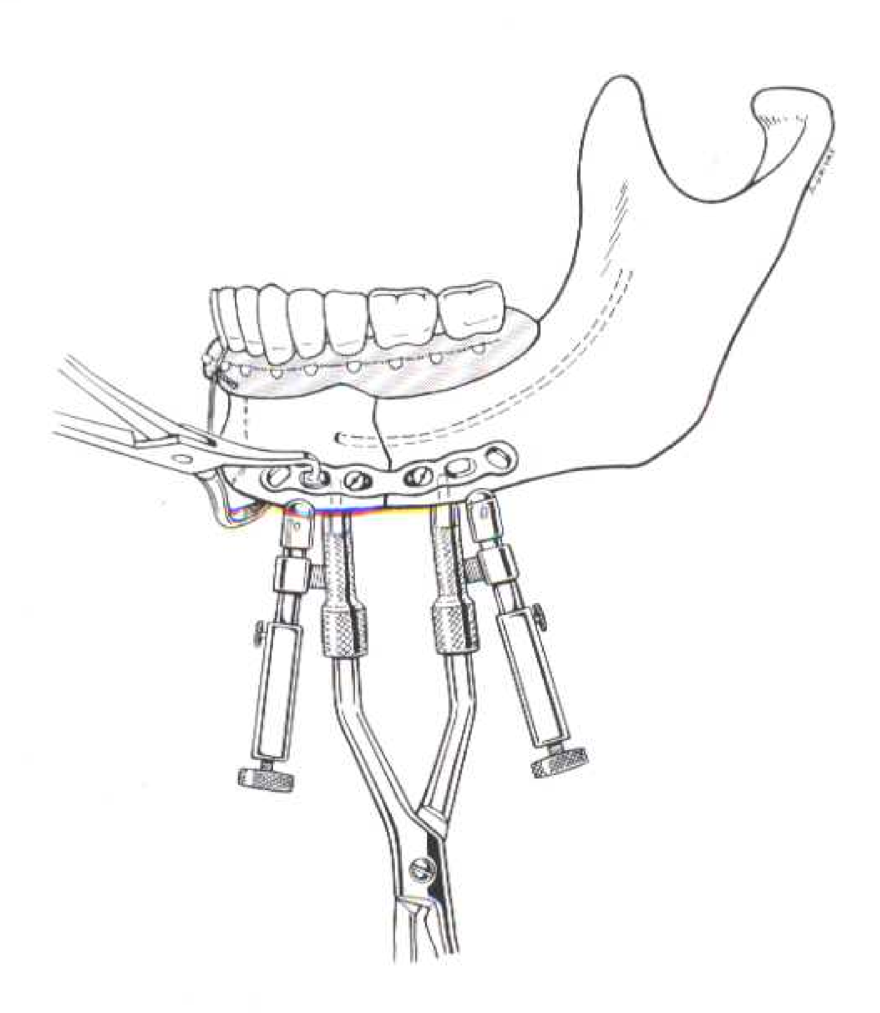


FIG. 5-171

The two superiorly directed compression screws are then placed bicortically, but only after the horizontal compression screws have been fully tightened. These are positioned inferiorly so that compression is directed toward the alveolar border of the fracture. The reduction pliers are then removed.

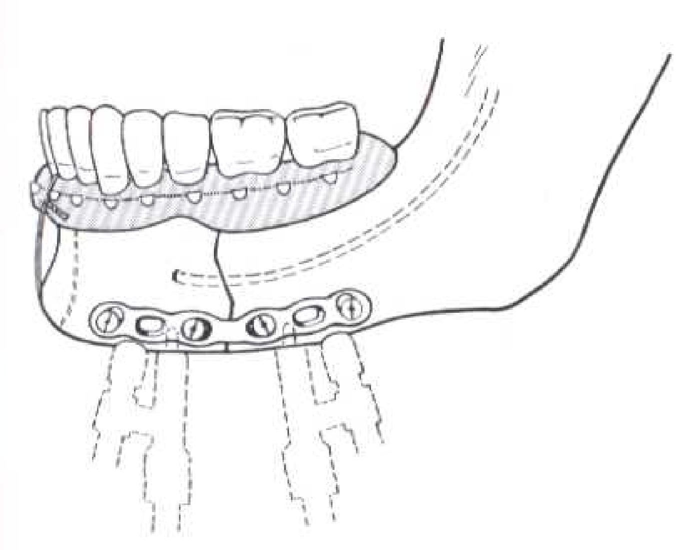


FIG. 5-172

Additional screws (when more than a four-hole plate has been used) are placed neutrally.

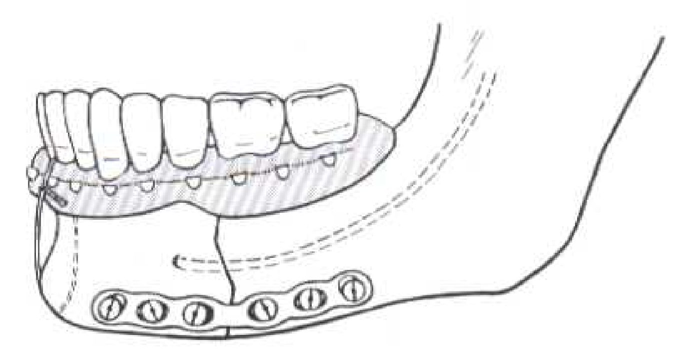


FIG. 5-173

The wound is irrigated, drained, and closed. IMF may now be removed.

MANDIBULAR RECONSTRUCTION PLATE

Key Principles	pp. 46, 68 (61, 62)
Surgical Approaches	
Intraoral	p. 74
Extraoral	p. 83

NOTE: *The mandibular reconstruction plate provides excellent stability, so much so that it can replace defective areas. It is thus excellent for adding stability when the underlying fractured bone is atrophic and weak. A long plate with numerous fixation points puts the weak area to rest, and it adds to the stability of the repair and, therefore, it increases the likelihood of healing.*

Occlusion is first established with dentures or splints when possible. An intraoral or extraoral approach may be used. In the pencil-thin mandible, the periosteum is left intact to whatever degree is possible to minimize devascularization of the bone.

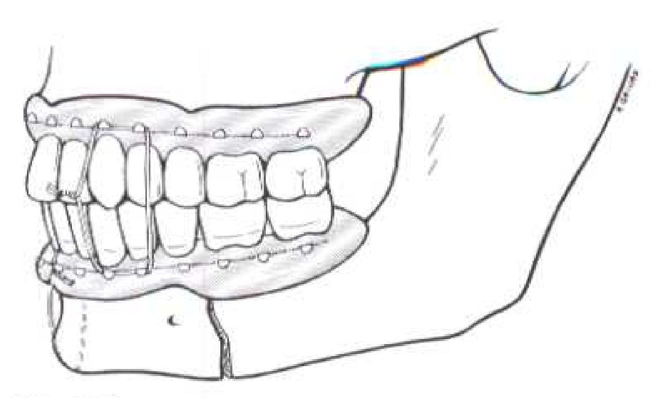


FIG. 5-174

(Optional) A modified towel clip may be used to hold the bone fragments in reduction. A drill is used to create a ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to precompress the fracture. In the body region, an extraoral approach is needed for this to be used.

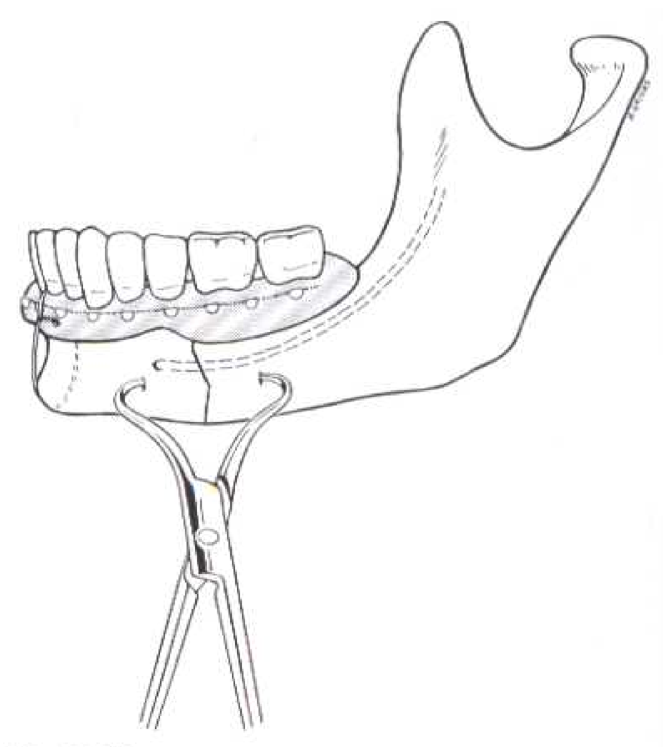


FIG. 5-175

(Optional) A mandibular reduction pliers with side rollers for superior compression may be applied along the inferior border. However, this may not be desirable in the thin atrophic mandible. If they are used, horizontal precompression is applied, the lock screw is tightened, and the rollers are used to compress the superior borders of the fragments. Care should be used to place the screws that hold the pliers to the mandible between the anticipated plate holes so that they do not interfere with plate application.

A reconstruction plate is selected and applied, taking care to bend it as precisely as possible to the template and to the bone. A plate-holding forceps helps to hold the plate in position for screw placement. At least four or five bicortical screws on each side of the fracture provide excellent structural support for the weak atrophic bone. The central screws may be placed eccentrically away from the fracture for compression if desired, but only if the mandibular height is only slightly higher than the plate; the remaining screws are placed neutrally.

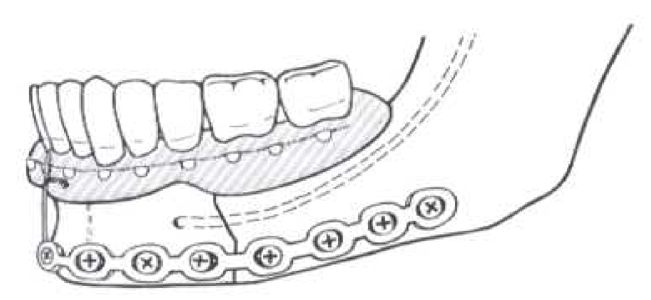


FIG. 5-176

Otherwise, all screws are positioned neutrally.

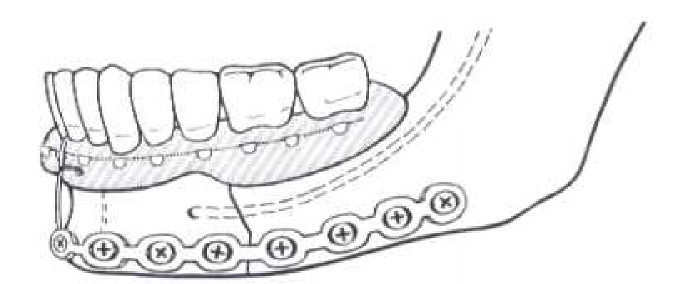


FIG. 5-177

The wound is irrigated, drained, and closed. IMF may now be removed.

CHAPTER *7*

Angle: Dentulous or Edentulous (Nonoverlapping)

1. An arch bar cannot serve as a tension band in this region because the fracture is generally behind the dentition or in the region of the third molar. Therefore, a distinction is not made between the dentulous and the edentulous mandible. However, as discussed earlier, establishing the proper occlusal relationship is nonetheless very important. The authors therefore recommend the use of IMF (by whatever means is most feasible) prior to the placement of rigid fixation devices to minimize the risk of creating a malocclusion (i.e., a malunion).

2. The issue of how to handle teeth in the line of fracture, particularly unerupted third molars, remains controversial. The decision of whether to extract or not to extract is up to the discretion of the surgeon and beyond the scope of this atlas.

3. Finally, it should be apparent that, for any intraoral approach to the mandibular angle, screws are placed through a percutaneous approach, using a transbuccal trochar. Care must be used to ensure proper plate positioning and contour when using this approach.

TENSION BAND PLATE AND COMPRESSION PLATE

Key Principles	pp. 42, 43, 61, 62
Surgical Approaches	
Intraoral	p. 77
Extraoral	p. 83

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that for intraoral plate application, a transbuccal approach for drilling and screw application is necessary.

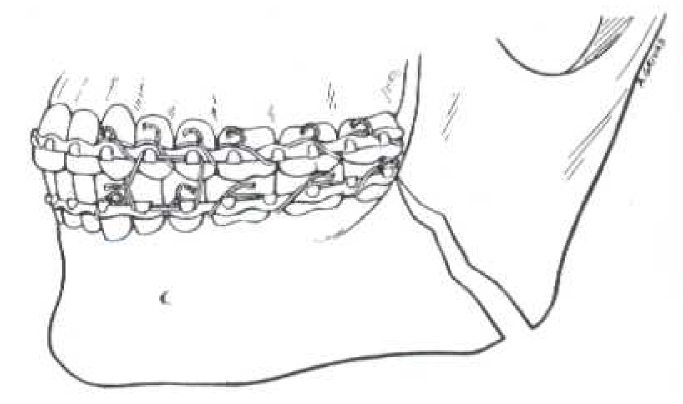


FIG. 5-178

For intraoral repair, no reduction device can be applied. However, a bone-holding clamp of some type can be used to manipulate the posterior bone fragment and reposition it.

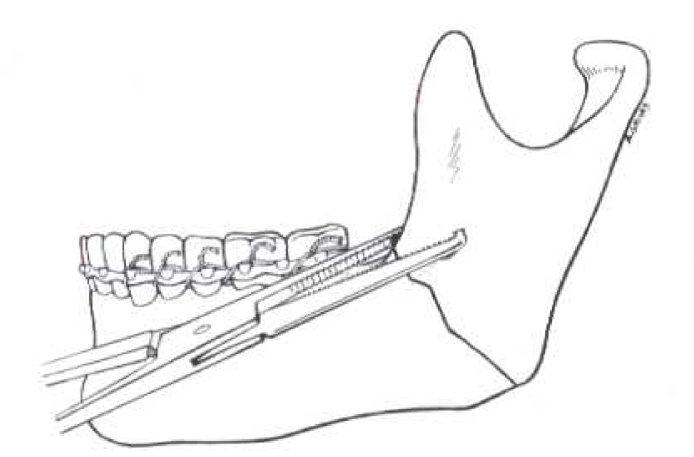


FIG. 5-179

When an external incision is used, reduction may be accomplished using modified towel clips or bone clamps. When towel clips are used, a drill is used to create a small ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to reduce and compress the fracture fragments together, taking care to realign the thin bones carefully.

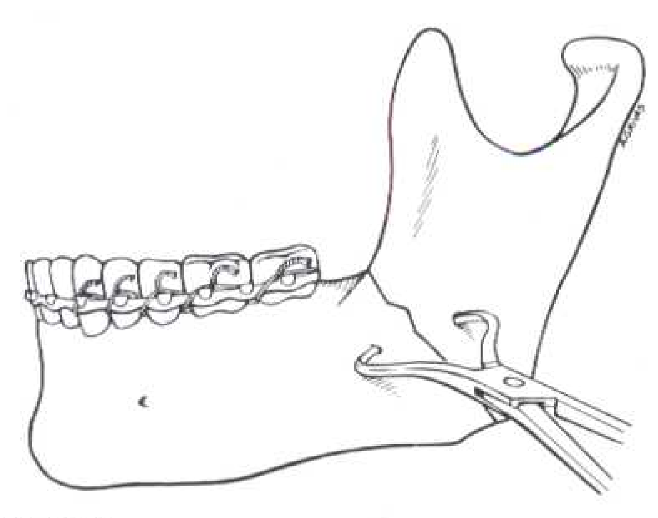


FIG. 5-180

(Optional) As an alternative, when an extraoral approach is used, reduction pliers with side rollers may be applied for precompression. Note that the application of these pliers may be difficult in the angle region as a result of the presence of the angle itself and the thinness of the bone posteriorly. Horizontal precompression is first applied, and the rollers are then tightened for vertical precompression. Note also that the pliers do not work well and may even serve to distract the fracture if a tooth in the line of the fracture has been extracted. Care should be taken to place the screws that fix the pliers to the mandible between the anticipated plate holes to avoid interference with plate application. These screws should also be placed approximately parallel to the fracture line to achieve the best results.

(Option 1) A two-hole compression plate may be used as a tension band. This plate is positioned so that it is applied above the inferior alveolar nerve. This plate is carefully positioned and bent to match the mandibular contour (an intervening template may be used if necessary). Bicortical screws are placed eccentrically away from the fracture to produce compression of the fragments.

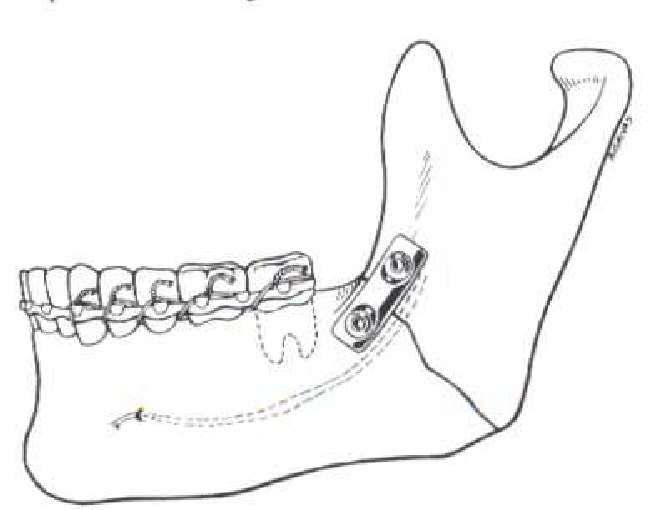


FIG. 5-181

(It has been suggested that, in the presence of an unerupted third molar, this plate can be applied with one of the screws passing directly through the tooth for better holding power. This mandates later removal of the plate and extraction of the tooth after the fracture has healed. This technique is not advocated by the authors.)

(Option 2) A four-hole or longer miniplate may be used as a tension band. (Option 2a) This is positioned across the fracture along the oblique line and bent to shape. Care must be taken to avoid tooth roots and the inferior alveolar nerve. Monocortical screws are placed sequentially. It is usually easier to place the posterior screws first. The posterior fragment is pulled anteriorly, reducing the fracture and making placement of the anterior screws easier.

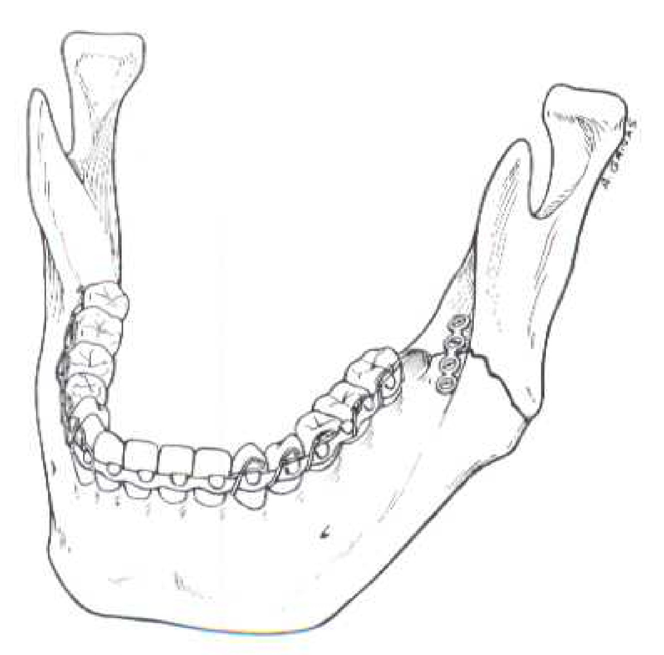


FIG. 5-182

(Option 2b) This is positioned along the buccal cortex across the fracture site above the inferior alveolar nerve and bent to shape. Screws are placed sequentially, making sure to drill the holes only through the outer cortex to avoid possible injury to tooth roots and/or the inferior alveolar nerve. At least four self-tapping miniscrews should be placed. (Bicortical screws may be used if the surgeon is absolutely certain that the nerve and the teeth are avoided, but monocortical screws provide adequate stability with this technique.)

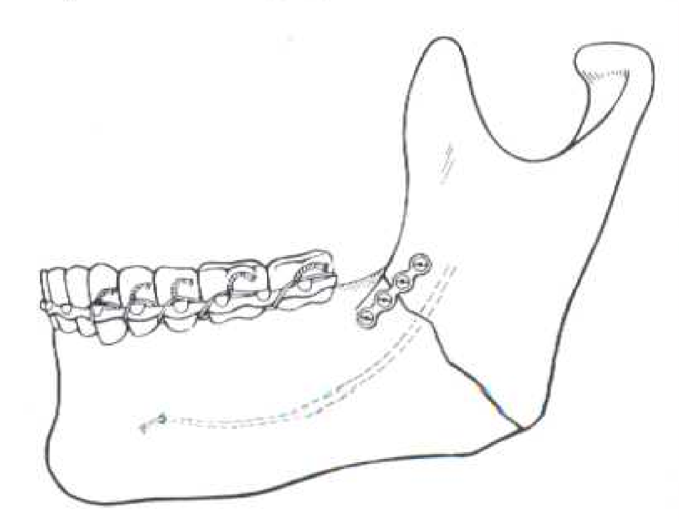


FIG. 5-183

An appropriate compression plate is selected, choosing at least a four-hole plate, although a six-hole plate is preferable because of the relatively weak holding power of the thin posterior bone. This plate must be positioned below the inferior alveolar nerve. The plate may be held in place with plate-holding forceps after precise bending to the mandibular contour has been successfully completed, usually bending a template first and then bending the plate.

Plate application is completed by using two bicortical compression screws and two to four bicortical neutral screws, depending on the length of the plate selected. Because a tension band plate has been applied, the technique for applying the inferior compression plate is the same whether the tension band plate is a monocortically applied miniplate or a two-hole compression plate.

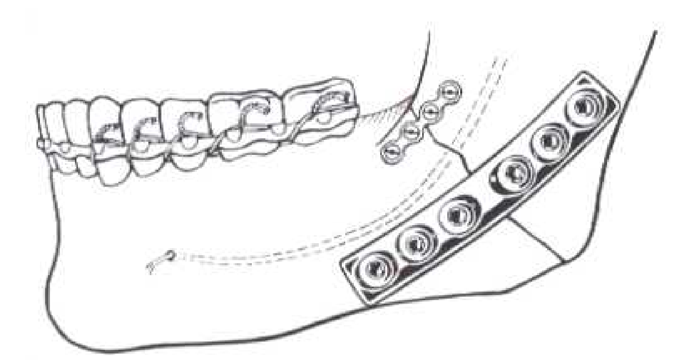


FIG. 5-184

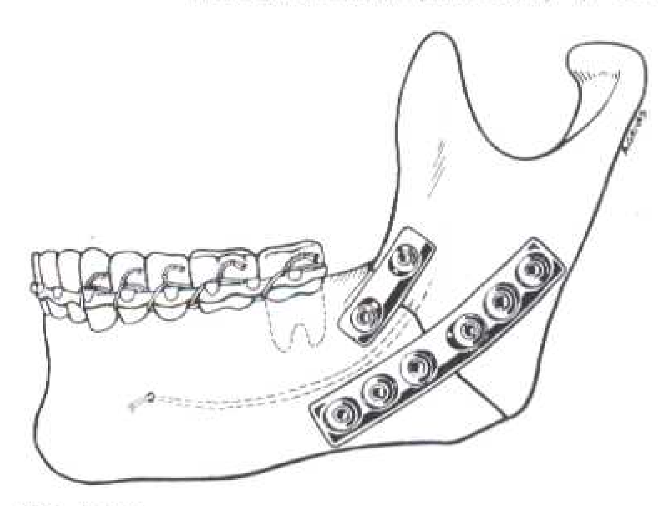


FIG. 5-185

(When a mandibular reduction pliers has been used, the locking screw is released after the two compression screws have been placed, and the pliers may be removed completely at any time after four screws have been placed.)

The wound is irrigated, drained, and closed. IMF may now be released.

MINIPLATE TECHNIQUES

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 77
Extraoral	p. 83

NOTE: *The authors recommend the use of two miniplates to overcome the varying forces acting on the angle region. There are three possible combinations of two miniplates:*

1. Oblique line and superior buccal

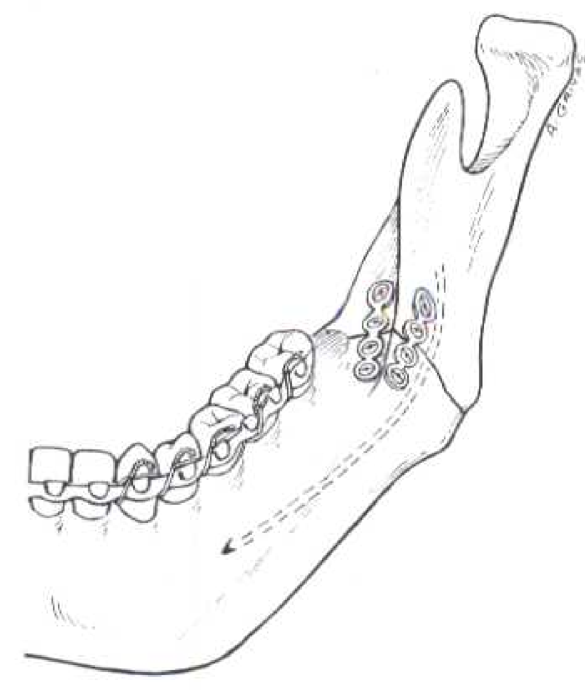


FIG. 5-186

2. Oblique line and inferior buccal

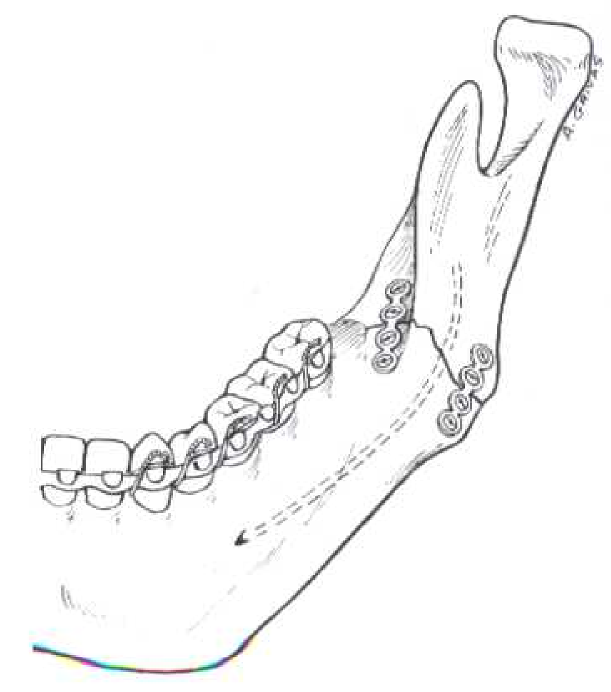


FIG. 5-187

3. Superior buccal and inferior buccal.

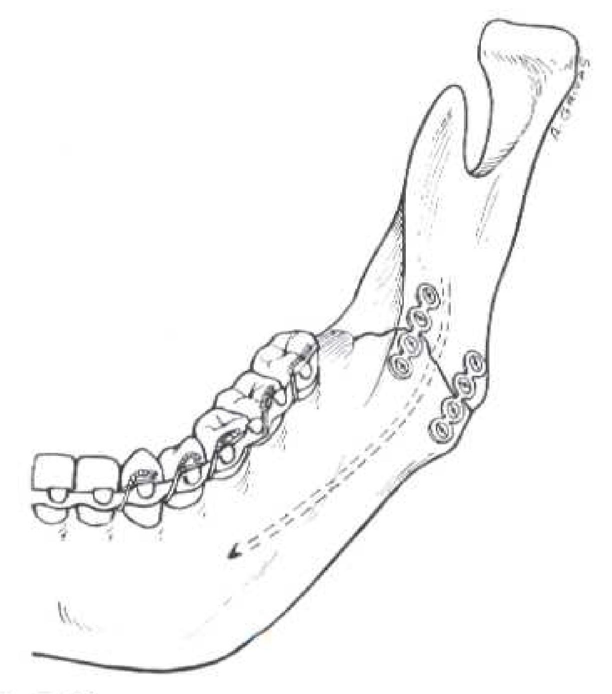


FIG. 5-188

There are some data that suggest that option 1, oblique line with superior buccal may be best, although at the time of this writing, the data were inconclusive. Although not advocated, placing miniplates at all three locations may be optimal.

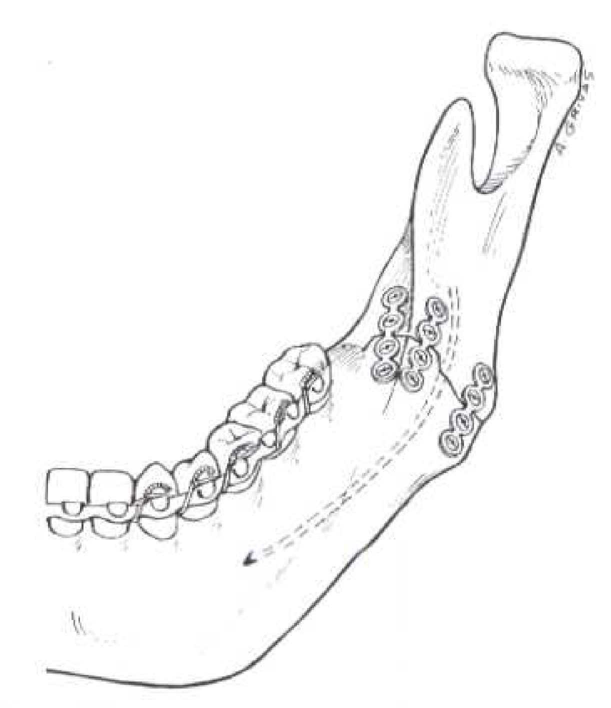


FIG. 5-189

Oblique Line and Second Plate

Occlusion is first established by the appropriate means. The fracture is exposed intraorally.

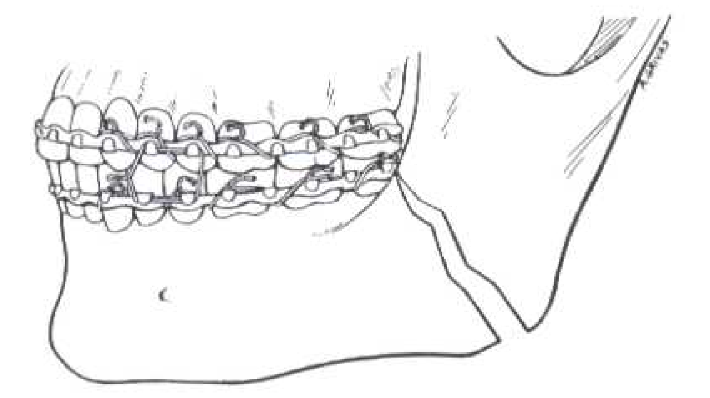


FIG. 5-190

For intraoral repair, no reduction device can be applied. However, a bone-holding clamp of some type can be used to manipulate the posterior (proximal) bone fragment and reposition it.

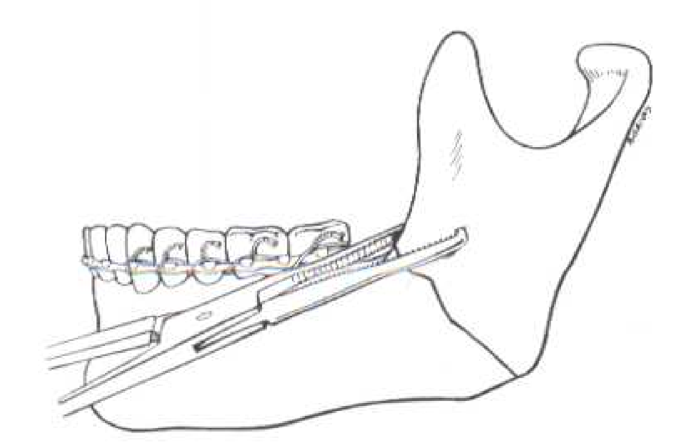


FIG. 5-191

A four-hole or longer miniplate is selected. This is positioned across the fracture along the oblique line and bent to shape. Care must be taken to avoid tooth roots and the inferior alveolar nerve. Monocortical screws are place sequentially. It is usually easier to place the posterior screws first. The posterior fragment is pulled anteriorly, reducing the fracture and making placement of the anterior screws easier.

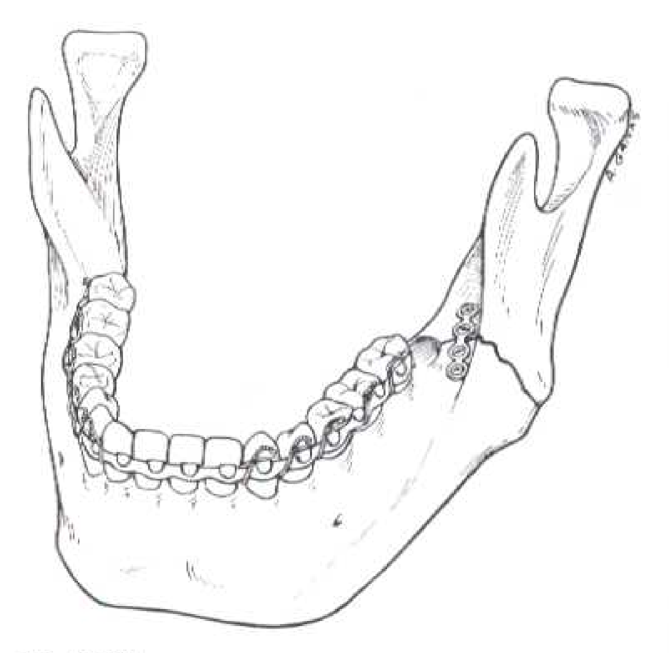


FIG. 5-192

(Option 1) A second miniplate is positioned along the buccal cortex across the fracture site above the inferior alveolar nerve and bent to shape. Screws are placed sequentially, making sure to drill the holes only through the outer cortex to avoid possible injury to tooth roots and/or the inferior alveolar nerve. At least four self-tapping miniscrews should be placed. (Bicortical screws may be used if the surgeon is absolutely certain that the nerve and the teeth are avoided, but monocortical screws provide adequate stability with this technique.)

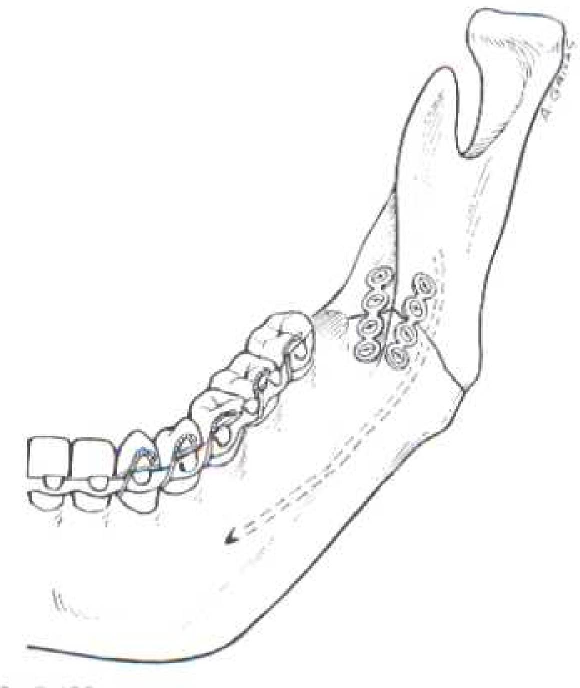


FIG. 5-193

(Option 2) A second miniplate is positioned inferiorly along the buccal side of the fracture below the inferior alveolar nerve and bent to shape. Screws are placed sequentially, using at least two screws on each side of the fracture. Monocortical or bicortical screws may be used because the nerve is not at risk if the plate is positioned properly. However, monocortical screws provide adequate stability with this technique.

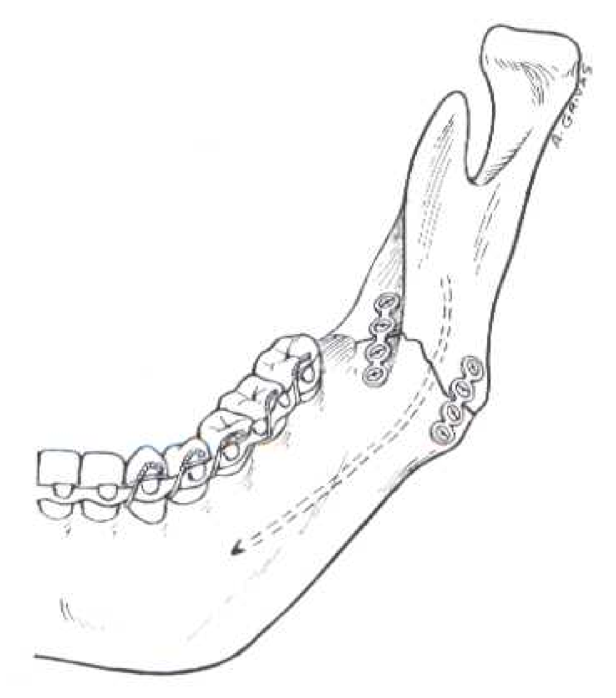


FIG. 5-194

The wound is irrigated, drained, and closed. IMF may now be released.

Lateral (Buccal) Placement Only

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that, for intraoral plate application, a transbuccal approach for drilling and screw application is necessary.

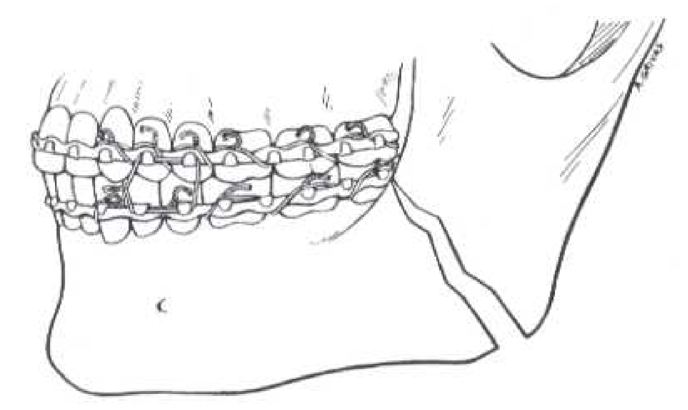


FIG. 5-195

For intraoral repair, no reduction device can be applied. However, a bone-holding clamp of some type can be used to manipulate the posterior (proximal) bone fragment and reposition it.

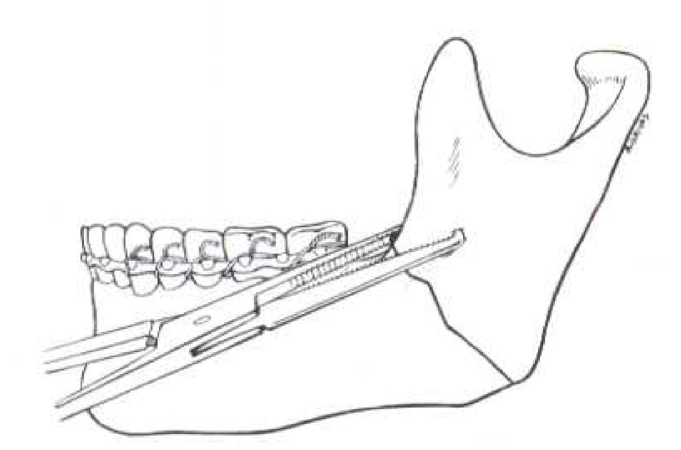


FIG. 5-196

(Optional) When an external incision is used, reduction may be accomplished by using modified towel clips or bone clamps. When towel clips are used, a drill is used to create a small ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to reduce and compress the fracture fragments together, taking care to realign the thin bones carefully.

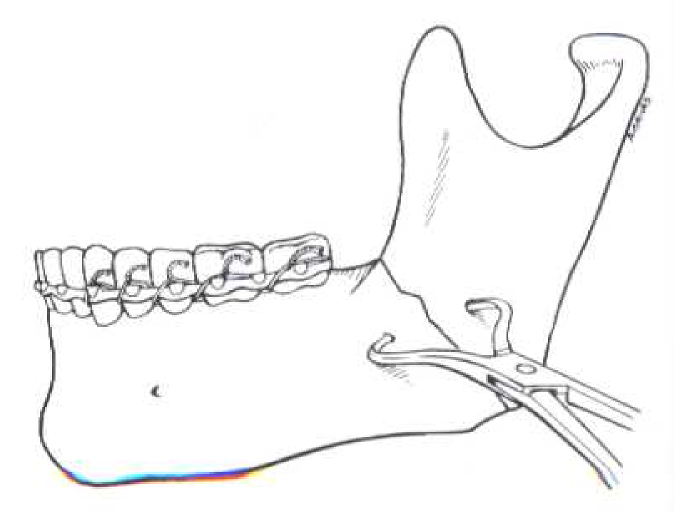


FIG. 5-197

(Optional) As an alternative, when an extraoral approach is used, reduction pliers with side rollers may be applied for stabilization and precompression. Note that the application of these pliers may be difficult in the angle region because of the presence of the angle itself and the thinness of the bone posteriorly. Horizontal precompression is first applied, and the rollers are then tightened for vertical precompression. Note that the pliers do not work well and may even serve to distract the fracture if a tooth in the line of fracture has been extracted. Care should be used to place the screws for the pliers between the anticipated plate holes to avoid interference with plate application. These screws should also be placed approximately parallel to the fracture line to achieve the best results.

A four-hole or longer miniplate is selected. This is positioned along the buccal (lateral) side of the mandible and bent to shape. Take care to position it above the inferior alveolar nerve. Screws are placed sequentially. Make sure to drill the holes only through the outer cortex to avoid possible injury to tooth roots and/or the inferior alveolar nerve. At least four self-tapping miniscrews should be placed. (Bicortical screws may be used if the surgeon is absolutely certain that the nerve and the teeth are avoided, but monocortical screws provide adequate stability with this technique.)

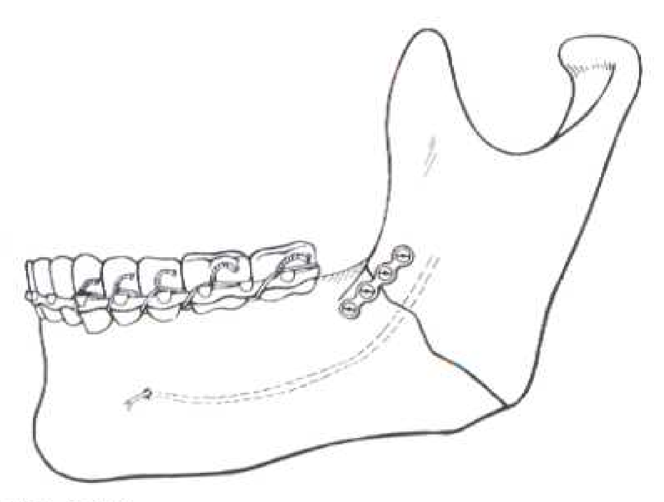


FIG. 5-198

A second miniplate is positioned inferiorly along the buccal side of the fracture below the inferior alveolar nerve and bent to shape. Screws are placed sequentially, using at least two screws on each side of the fracture. Monocortical or bicortical screws may be used because the nerve is not at risk if the plate is positioned properly. However, monocortical screws provide adequate stability with this technique.

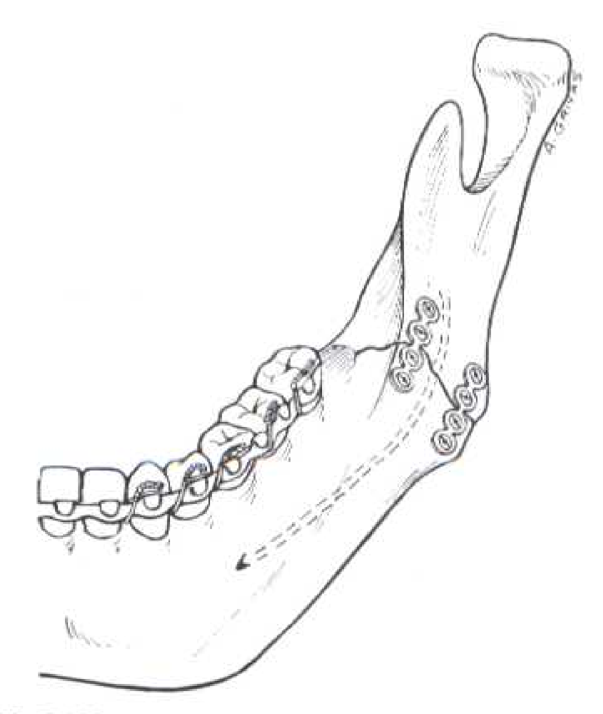


FIG. 5-199

The wound is irrigated, drained, and closed. IMF may now be released.

EDCP

Key Principles	pp. 44, 66
Surgical Approaches	
Extraoral	p. 83

NOTE: *Although this plate can be used effectively in this region, it is probably not the safest or strongest repair available. This is particularly true if there has been any bone loss superiorly or if a tooth has been lost or extracted. Furthermore, because of the difficulty of proper EDCP application, especially in this region, an extraoral approach and use of the reduction pliers with rollers are advised.*

Occlusion is first established by the appropriate means. The fracture is exposed, extraorally.

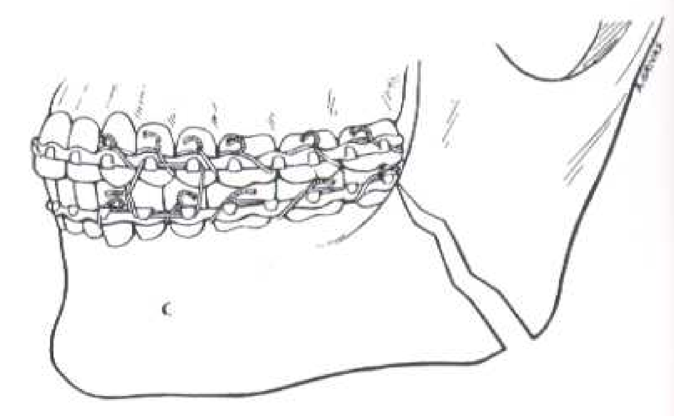


FIG. 5-200

When using an EDCP, the alveolar border (traction side) of the mandible must be precompressed. A modified towel clip may be used, although the mandibular reduction pliers with side rollers for superior precompression is recommended. Note that the application of the pliers can be difficult in the angle region as a result of the presence of the angle itself and the thinness of the bone posteriorly. The screws that hold the pliers to the mandible should be placed approximately parallel to the fracture line to achieve the best results. Care should be used to place the screws for the pliers between anticipated plate holes so that they do not interfere with plate application. Horizontal precompression is first applied, and then the lock nut is tightened. The rollers are then carefully tightened to produce vertical compression. Note that this does not work well if there is bone loss at the alveolar border or if a tooth has been extracted.

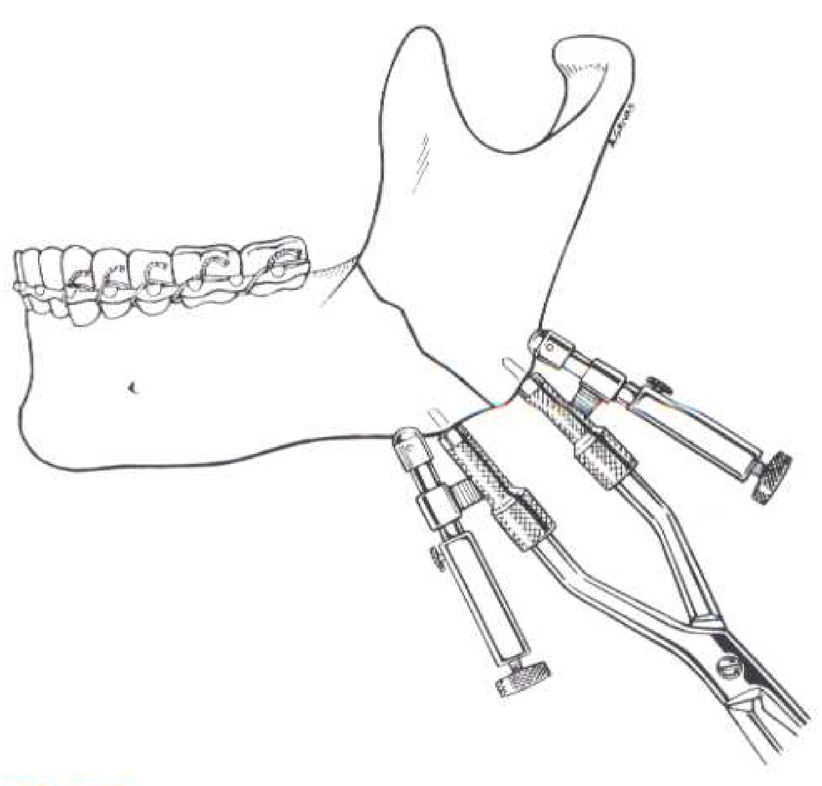


FIG. 5-201

An appropriate EDCP is selected and positioned inferiorly below the inferior alveolar nerve. At least a six-hole plate is recommended in this area. Because the EDCP has a top and a bottom, care must be used to make certain that this plate is not applied upside down. **The diagonal holes should point superiorly toward the fracture line!** A template is usually bent to shape first. The plate is then carefully bent to match the template and then, ultimately, the bone. After precise bending to match the mandibular contour has been completed, the plate is positioned and held in place with a plate-holding forceps.

First, the two horizontal compression screws are placed bicortically, positioning them away from the fracture to produce horizontal compression. The locking screw on the reduction pliers is released.

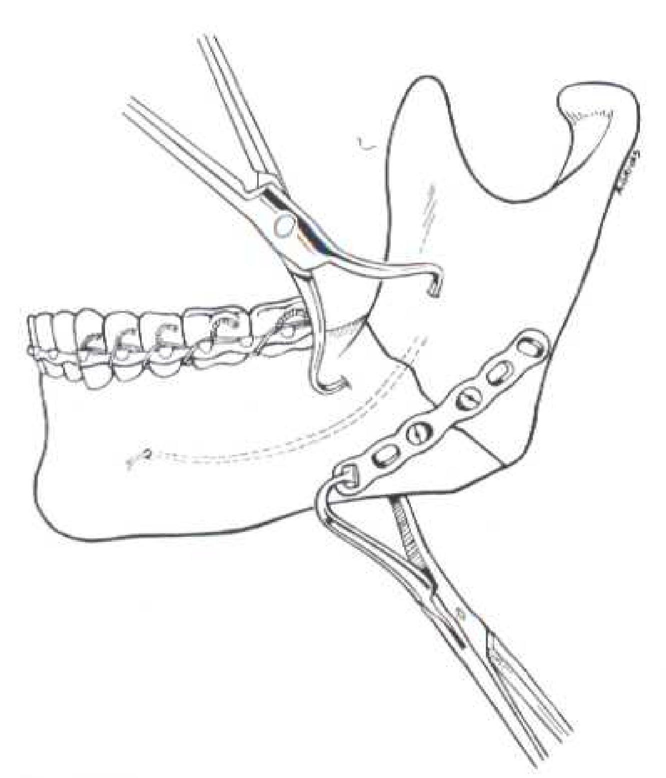


FIG. 5-202

The superiorly directed compression screws are then placed bicortically, but only after the horizontal compression screws have been fully tightened. These are positioned inferiorly so that compression is directed toward the alveolar border of the fracture. The reduction pliers are then removed.

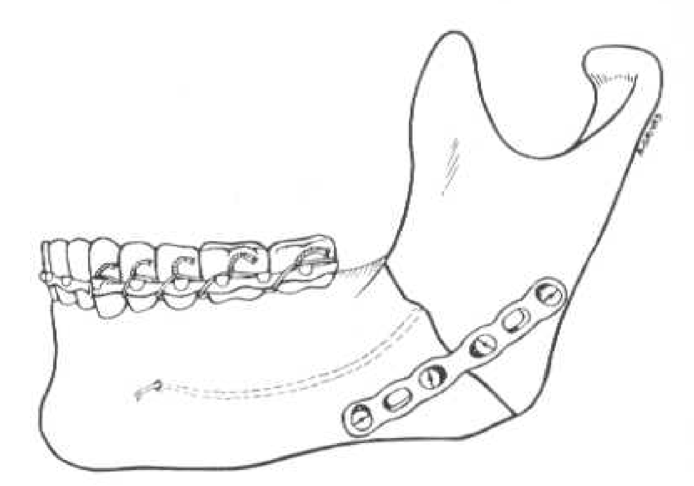


FIG. 5-203

Additional screws (when more than a four-hole plate has been used), are placed neutrally.

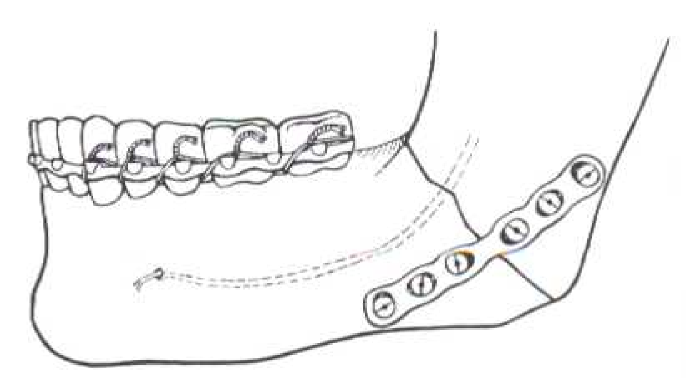


FIG. 5-204

The wound is irrigated, drained, and closed. IMF may now be released.

ANGLED COMPRESSION PLATE

Key Principles	pp. 43, 62
Surgical Approaches	
Intraoral	p. 77
Extraoral	p. 83

NOTE: *This plate has been specifically designed to apply compression across the angle region in a direction that pulls the body of the mandible posterosuperiorly toward the ramus or vice versa.*

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that for intraoral plate application, a transbuccal approach for drilling and screw application is necessary.

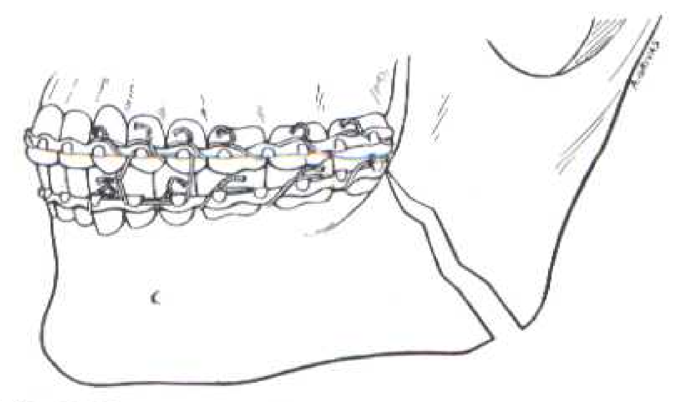


FIG. 5-205

For intraoral repair, no reduction device can be applied. However, a bone-holding clamp of some type can be used to manipulate the posterior (proximal) bone fragment and reposition it.

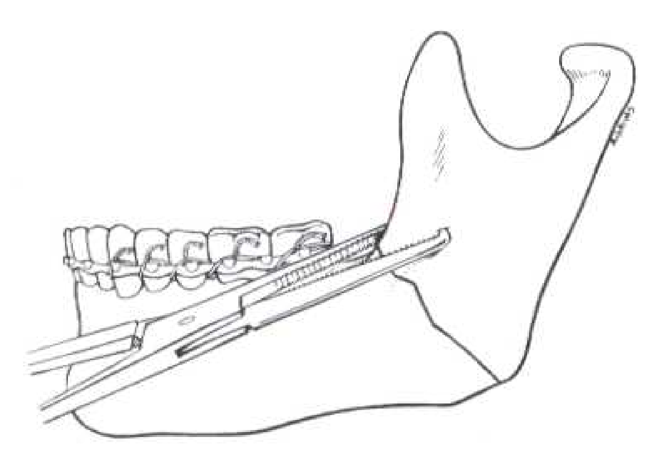


FIG. 5-206

When an external incision is used, reduction may be accomplished by using modified towel clips or bone clamps. When a towel clip is used, a drill is used to create a small ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to reduce and compress the fracture fragments together, taking care to realign the thin bones carefully.

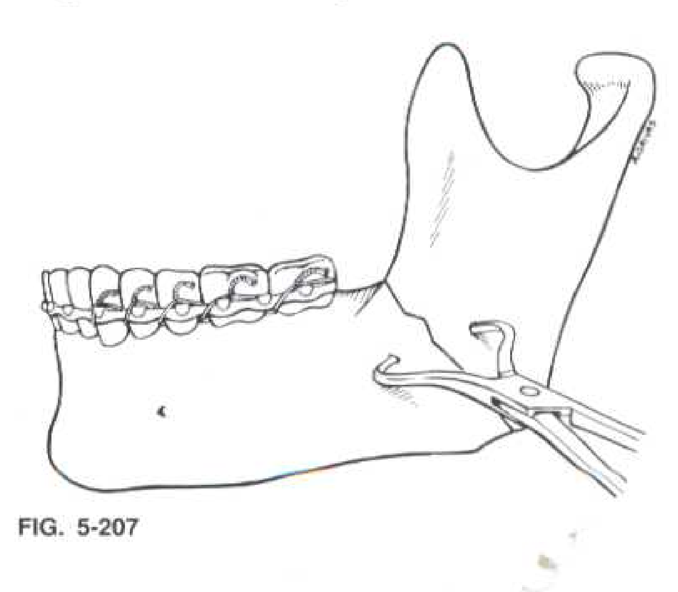


FIG. 5-207

(Optional) As an alternative, when an extraoral approach is used, reduction pliers with side rollers may be applied for precompression. Note that the application of these pliers may be difficult in the angle region as a result of the presence of the angle itself and the thinness of the bone posteriorly. Horizontal precompression is first applied, and the rollers are then tightened for vertical precompression. Note that the pliers do not work well and may even serve to distract the fracture if a tooth in the line of the fracture has been extracted. Care should be used to place the screws that fix the pliers to the mandible between the anticipated plate holes to avoid interference with plate application. These screws should also be placed approximately parallel to the fracture line to achieve the best results.

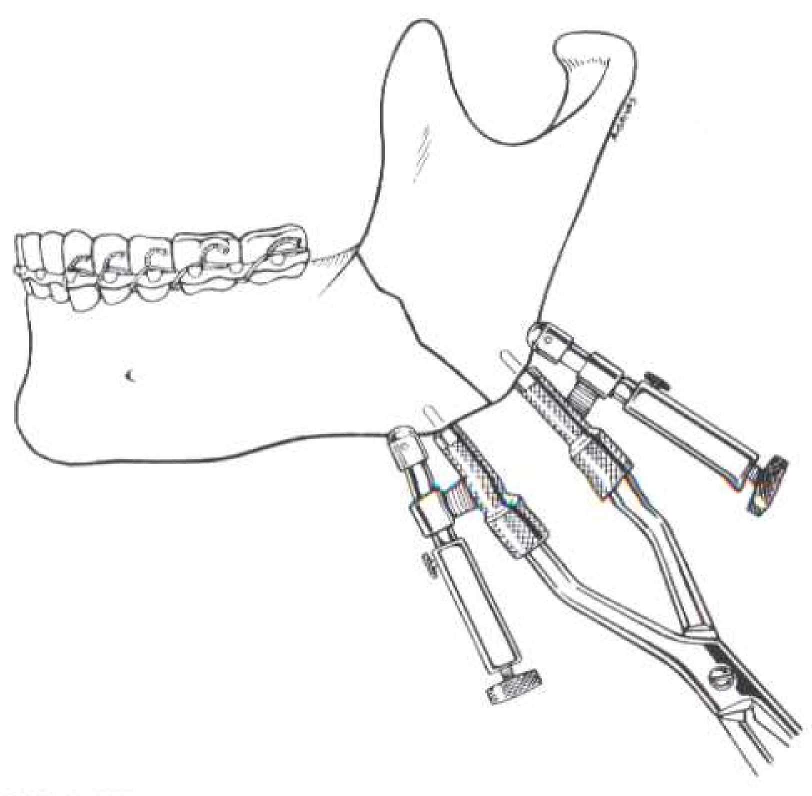


FIG. 5-208

An angled compression plate is selected and positioned so that it sits below and behind the inferior alveolar nerve. This plate is carefully bent to match the mandibular contour, generally by first bending a template and then bending the plate to match the template and, ultimately, the mandible.

When the neutral screws are in the posterior (proximal) fragment, the plate is positioned, and these screws are applied bicortically, one at a time.

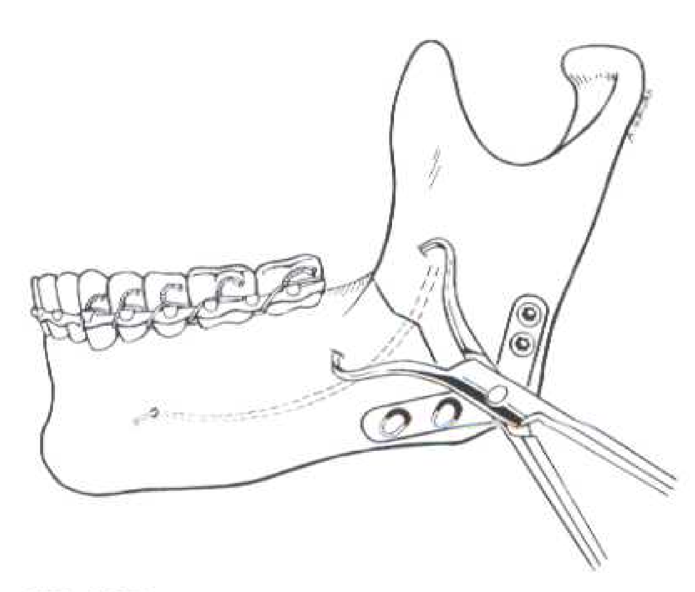


FIG. 5-209

The posterior fragment is pulled forward into reduction and held there. The bicortical compression screws are then placed in the anterior (distal) fragment. These are positioned inferiorly in the holes so that compression forces are directed posterosuperiorly, thereby compressing the fractured fragments together.

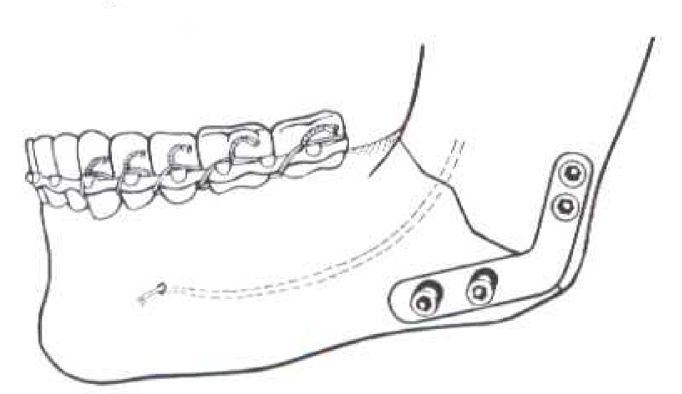


FIG. 5-210

When the neutral screws are in the anterior (distal) fragment, the plate is positioned, and these screws are applied bicortically one at a time.

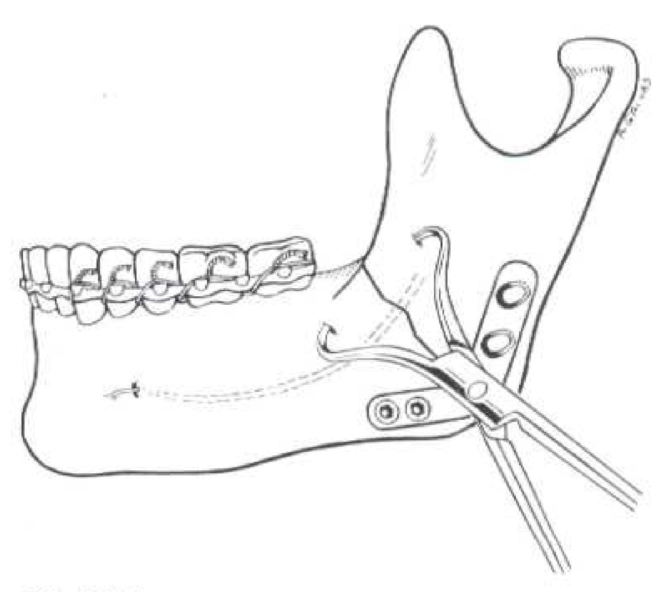


FIG. 5-211

The posterior fragment is pulled forward into reduction and held there. The bicortical compression screws are then placed in the posterior fragment. These are positioned posterosuperiorly in the plate holes so that compression forces are directed anteroinferiorly, thereby stabilizing the plate to the posterior fragment and resulting in compression across the fracture line.

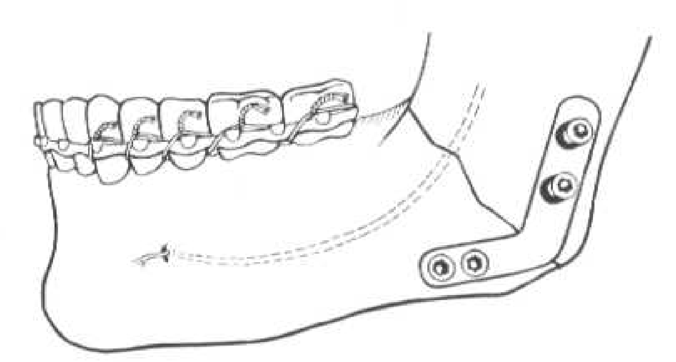


FIG. 5-212

The wound is irrigated, drained, and closed. IMF may now be released.

MANDIBULAR RECONSTRUCTION PLATE WITH OR WITHOUT TENSION BAND PLATE

Key Principles	pp. 46, 68 (61, 62)
Surgical Approaches	
Intraoral	p. 77
Extraoral	p. 83

NOTE: *The mandibular reconstruction plate is designed to be able to replace missing segments of bone. It therefore can serve as an alternative fixation technique for any fracture as long as adequate fixation is applied (generally at least three to four screws on each side of the fracture). For the thin bone in the angle region, the plate provides additional stability and may decrease the infection and nonunion rate, especially when a tooth has been lost or needs to be extracted.*

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that for intraoral plate application, a transbuccal approach for drilling and screw application is necessary. Also note that, when a long plate is used, more than one transbuccal stab may be needed.

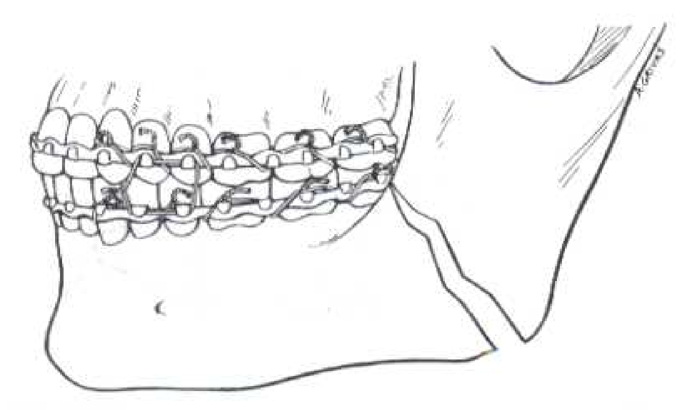


FIG. 5-213

For intraoral repair, no reduction device can be applied. However, a bone-holding clamp of some type can be used to manipulate the posterior (proximal) bone fragment and reposition it.

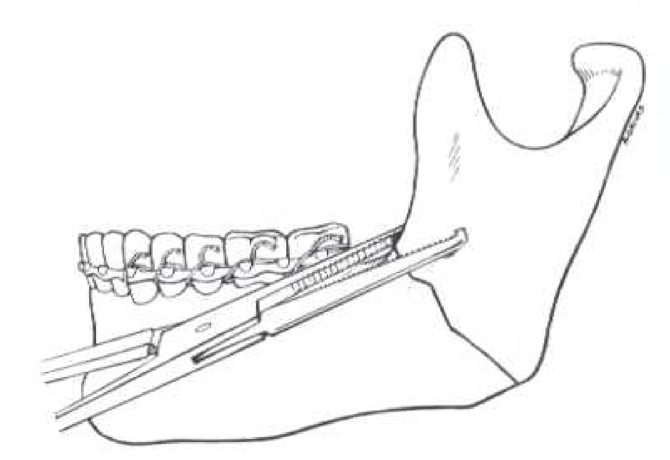


FIG. 5-214

When an external incision is used, reduction may be accomplished by using modified towel clips or bone clamps. When towel clips are used, a drill is used to create a small ledge in the bone on each side of the fracture for purchase by the towel clip prongs. The towel clip is then used to reduce and compress the fracture fragments together, taking care to realign the thin bones carefully.

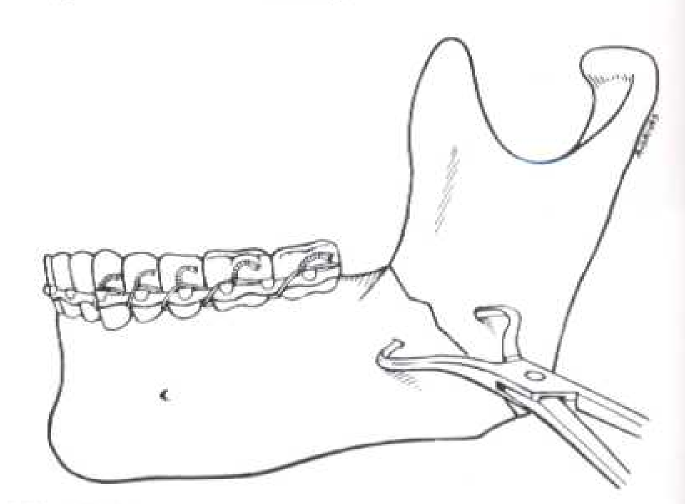


FIG. 5-215

(Optional) As an alternative, when an extraoral approach is used, reduction pliers with side rollers may be applied for precompression. Note that the application of these pliers may be difficult in the angle region as a result of the presence of the angle itself and the thinness of the bone posteriorly. Horizontal precompression is first applied, and the rollers are then tightened for vertical precompression. Note that the pliers do not work well and may even serve to distract the fracture if a tooth in the line of fracture has been extracted. Care should be used to place the screws that fix the pliers to the mandible between the anticipated plate holes to avoid interference with plate application. These screws should also be placed approximately parallel to the fracture line to achieve the best results.

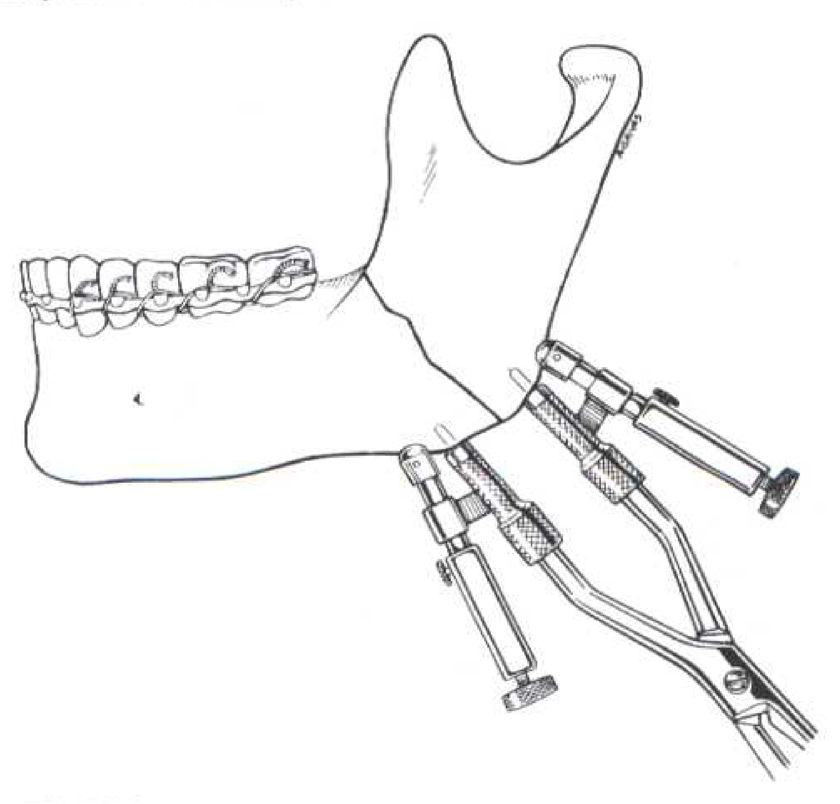


FIG. 5-216

(Optional) A tension band plate may be used along with the reconstruction plate. The tension band plate should be applied first.

(Option 1) A two-hole compression plate may be used as a tension band. This plate is positioned so that it is applied above the inferior alveolar nerve. This plate is carefully positioned and bent to match the mandibular contour (an intervening template may be used if necessary). Bicortical screws are placed eccentrically away from the fracture to produce compression of the fragments.

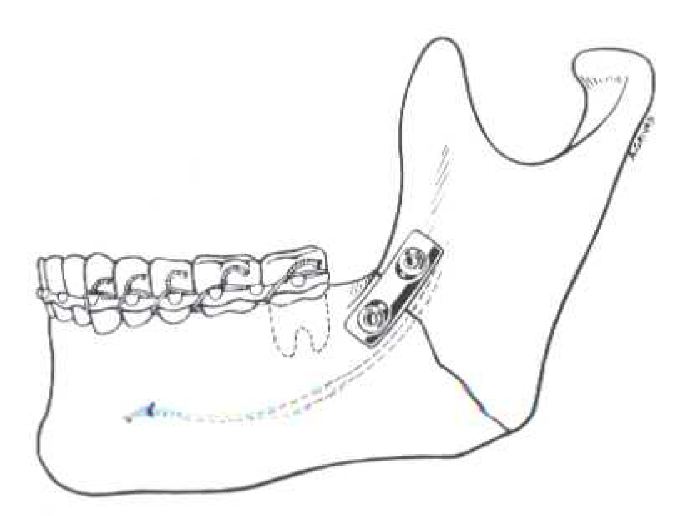


FIG. 5-217

(It has been suggested that, in the presence of an unerupted third molar, this plate can be applied with one of the screws passing directly through the tooth for better holding power. This mandates later removal of the plate and extraction of the tooth after the fracture has healed. This technique is not advocated by the authors.)

(Option 2) A four-hole or longer miniplate may be used as a tension band. (Option 2a) This is positioned across the fracture along the oblique line and bent to shape. Care must be taken to avoid tooth roots and the inferior alveolar nerve. Monocortical screws are placed sequentially. It is usually easier to place the posterior screws first. The posterior fragment is pulled anteriorly, reducing the fracture and making placement of the anterior screws easier.

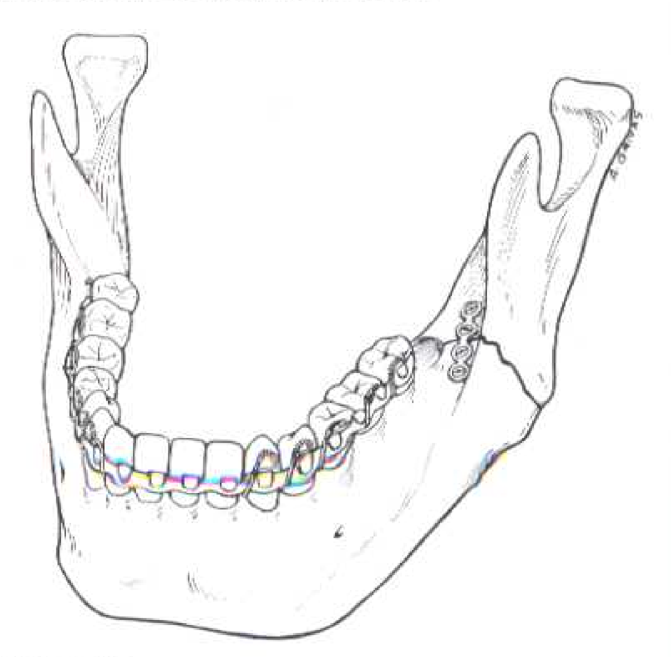


FIG. 5-218

(Option 2b) This is positioned along the buccal cortex across the fracture site above the inferior alveolar nerve and bent to shape. Screws are placed sequentially. Make sure to drill the holes only through the outer cortex to avoid possible injury to tooth roots and/or the inferior alveolar nerve. At least four self-tapping miniscrews should be placed. (Bicortical screws may be used if the surgeon is absolutely certain that the nerve and the teeth are avoided, but monocortical screws provide adequate stability with this technique.)

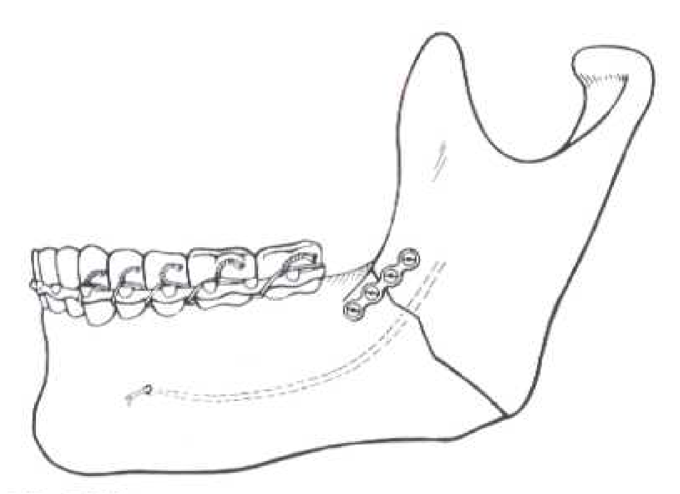


FIG. 5-219

An appropriate length of reconstruction plate is selected. At least three screws on each side of the fracture are recommended, although four or even five are preferred. Note that bending can be difficult, and prebent plates are preferable for the angle region when they can be successfully fitted. (Excessive bending significantly weakens plate strength.) A template is bent to match the mandibular contour, and the plate is carefully bent to match the template and, ultimately, the mandible. Take care to position the plate below and behind the inferior alveolar nerve.

If a tension band plate has been applied, then the first two bicortical screws may be placed eccentrically, providing axial compression across the fracture. The remaining four to eight screws are positioned neutrally, and any reduction devices are removed.

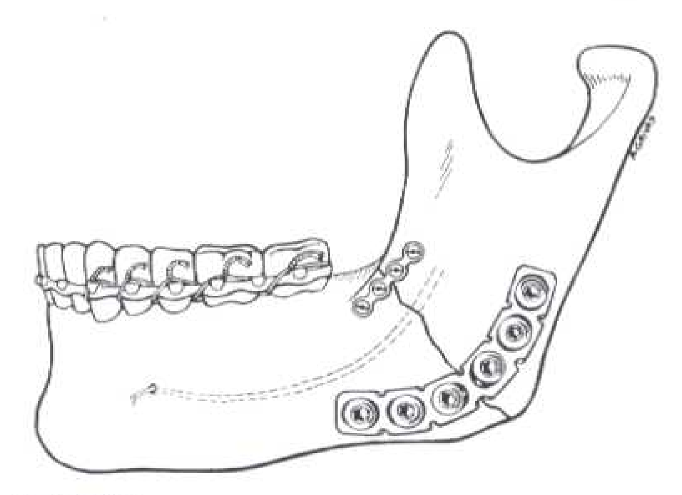


FIG. 5-220

If no tension band plate has been applied, then all screws are placed neutrally in the plate holes to avoid distracting forces along the alveolar portion of the fracture. Care is taken to position the plate below the inferior alveolar nerve so that bicortical screws may be used safely. At least six screws, but even eight or ten, are placed. Any reduction device present is removed.

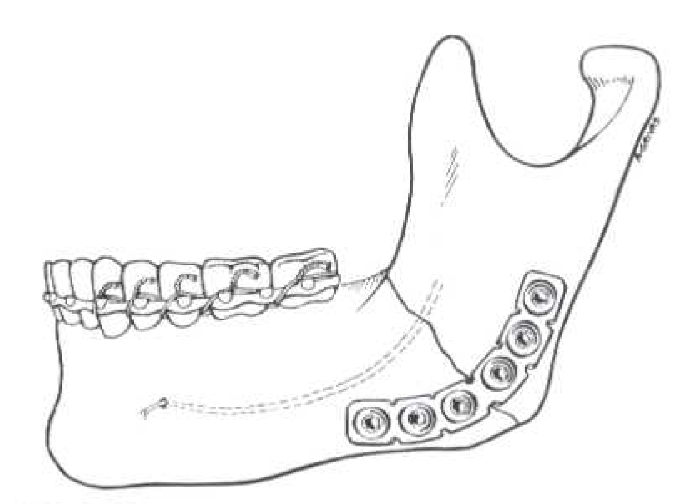


FIG. 5-221

The wound is irrigated, drained, and closed. IMF may now be removed.

LAG SCREW

Key Principles	pp. 47, 50
Surgical Approaches	
Intraoral	p. 77

NOTE: *When using this technique, long screws (38–44 mm) must be available.*

NOTE: *This is a difficult technique to master, and practice on models and cadavers is strongly recommended.*

Occlusion is first established by the appropriate means. The fracture is exposed intraorally and reduced.

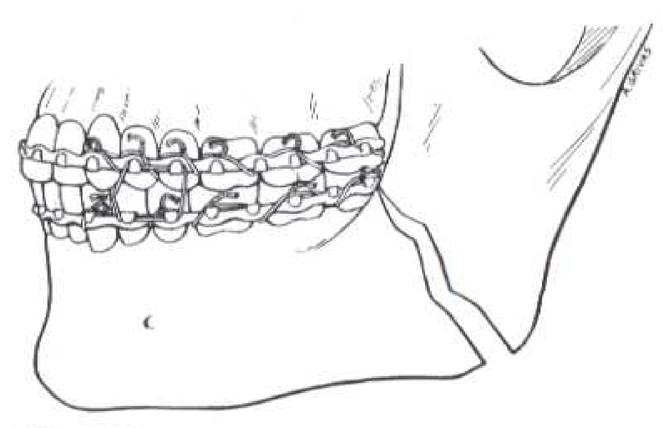


FIG. 5-222

For intraoral repair, no reduction device can be applied. However, a bone-holding clamp of some type can be used to manipulate the posterior (proximal) bone fragment and reposition it.

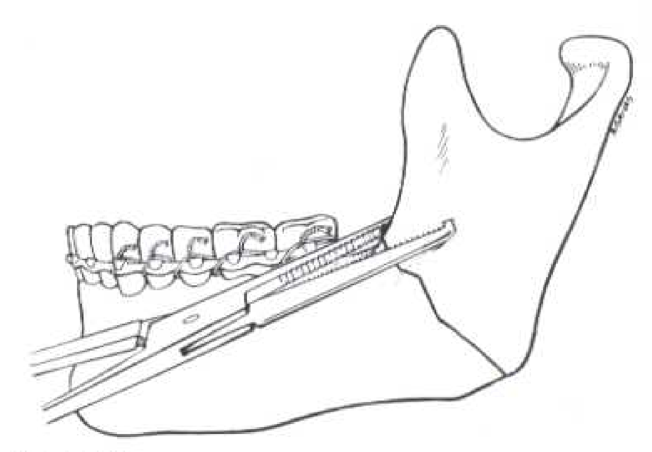


FIG. 5-223

The transbuccal trochar is introduced under the mandibular body at an angle from anterior to posterior and from inferior to superior. The site for drilling along the buccal portion of the mandibular body is identified by developing an angle that crosses the fracture from the buccal cortex of the mandibular body to the lingual cortex of the ramus, carefully avoiding the inferior alveolar nerve. This courses from anteroinferolateral to posterosuperomedial. A notch drilled perpendicularly in the bone allows for purchase of the drill.

The lateral cortex is drilled with a 2.7-mm drill bit. Be careful not to drill the second cortex.

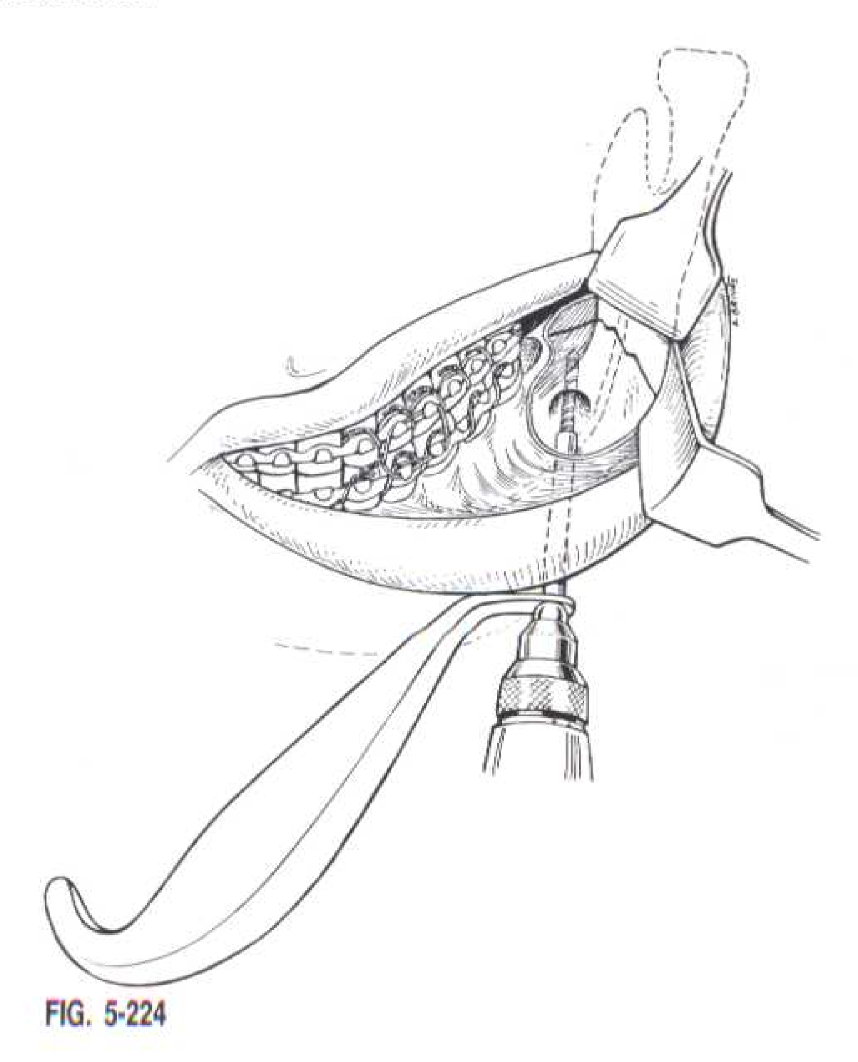


FIG. 5-224

The 2.0-mm sleeve may be introduced into this hole, and the posteromedial cortex is drilled with the 2.0-mm drill bit.

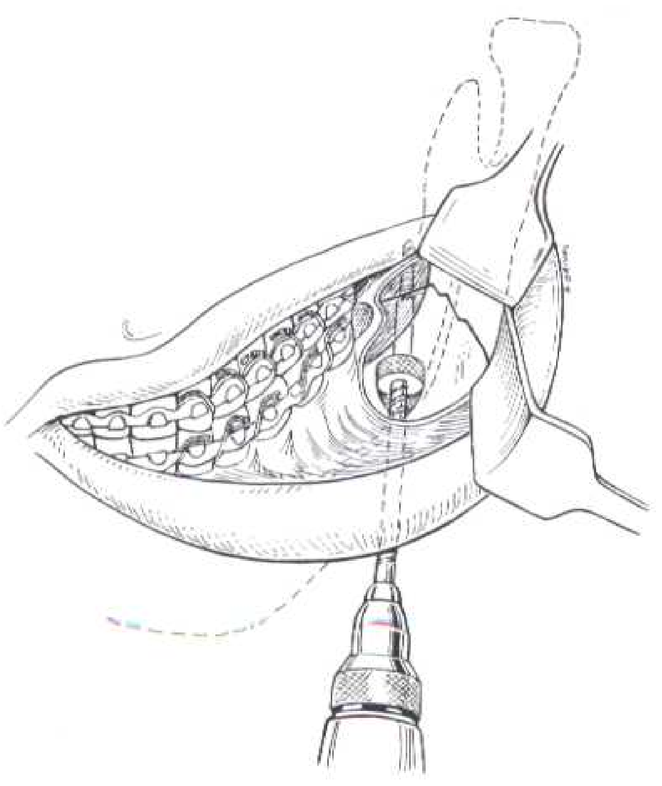


FIG. 5-225

A countersink is used to enlarge the drill hole for better seating of the screw head. A depth gauge is used to measure the full length of the hole, which is generally 24 to 30 mm in depth.

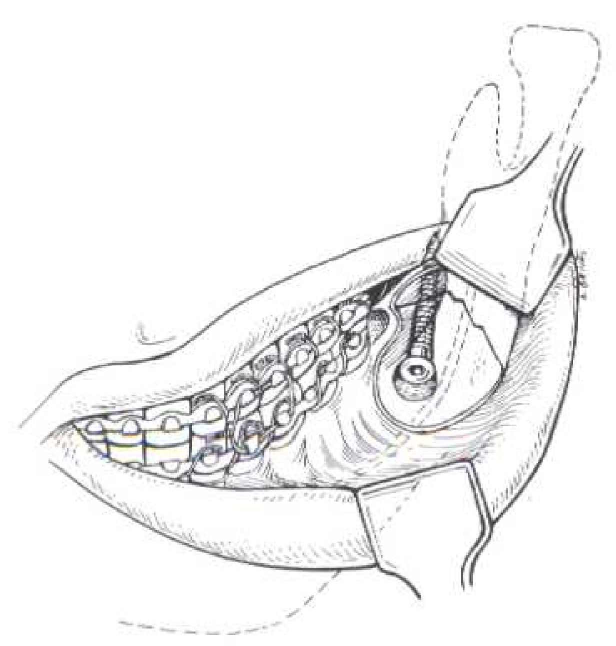
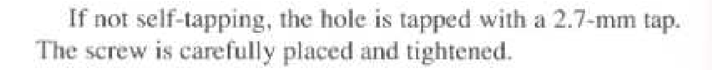


FIG. 5-226



If not self-tapping, the hole is tapped with a 2.7-mm tap. The screw is carefully placed and tightened.

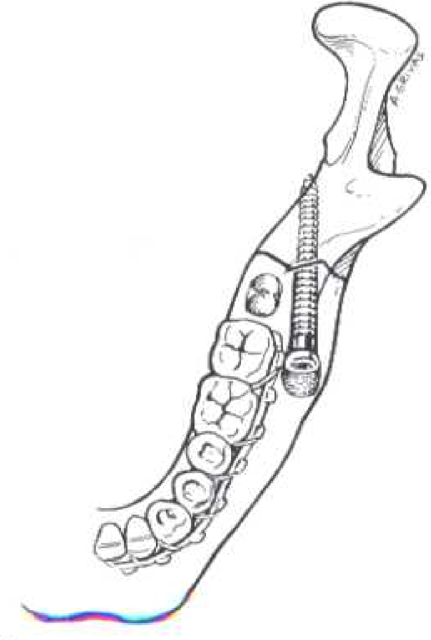


FIG. 5-227

The wound is irrigated, drained, and closed. IMF may now be released.

CHAPTER 8

Ramus: Horizontal Fractures (Above Lingula) (Dentulous or Edentulous)

An arch bar cannot serve as a tension band in this region because the fracture is behind the dentition. Therefore, distinction is not made between the dentulous and the edentulous mandible. However, the use of intraoperative IMF is still recommended to maintain the proper occlusal relationship. Note also that the mandibular ramus is thin and difficult to access.

MINIPLATES

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 80
Extraoral	p. 85

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that, for intraoral plate application, a transbuccal approach for drilling and screw application is necessary. Exposure is difficult because of the marked posterior position of the fracture.

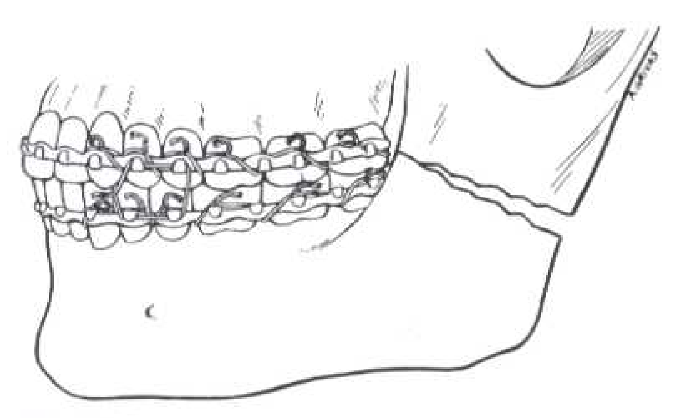


FIG. 5-228

Reduction is carried out manually or with a bone-holding clamp. This is generally accomplished by grasping the proximal fragment and pulling it into reduction against the anterior fragment.

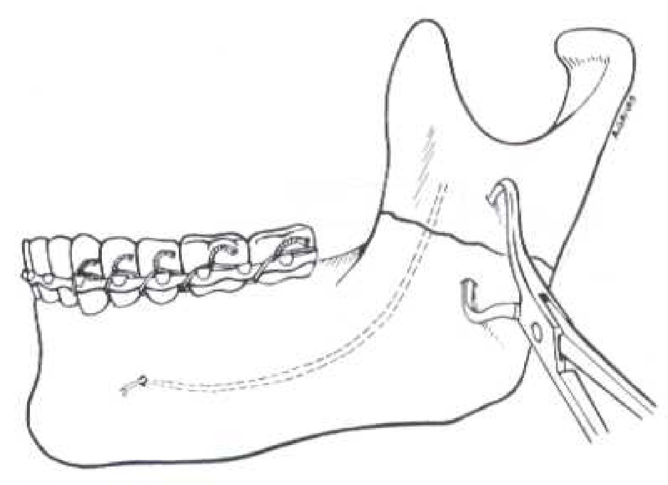


FIG. 5-229

(Optional) Reduction may be carried out using wire ligatures prior to plate application, particularly if there is gapping anteriorly, in which case a tension band wire is placed anteriorly and the plate is placed either centrally or posteriorly.

(Optional) A tension band miniplate may be applied along the anterior portion of the fracture, generally using a four-hole plate. Bicortical screws may be used in the thin bone here as long as care is taken to avoid the inferior alveolar nerve.

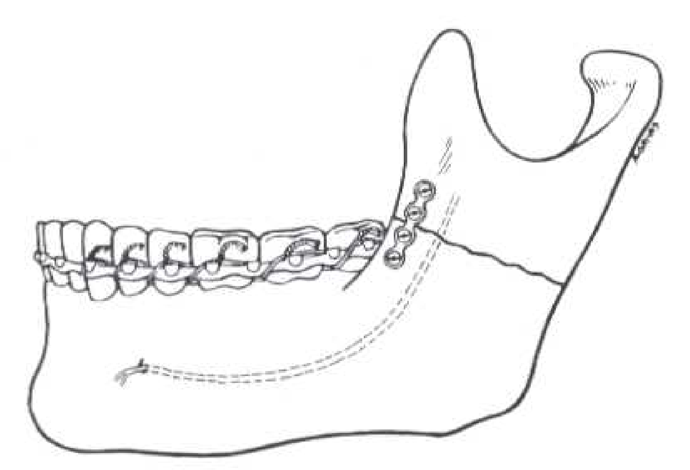


FIG. 5-230

If a single miniplate is used, it is best placed across the central portion of the fracture, taking care to avoid the inferior alveolar nerve at its entry point. Bicortical screws may then be placed in the the thin bone. At least a four-hole plate should be used. Screws are placed sequentially.

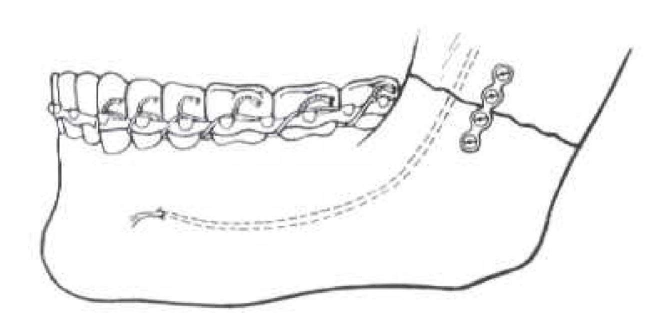


FIG. 5-231

If a tension band miniplate has been placed anteriorly, the second plate is placed posteriorly, again using at least a four-hole plate and sequential screw placement, using bicortical screws.

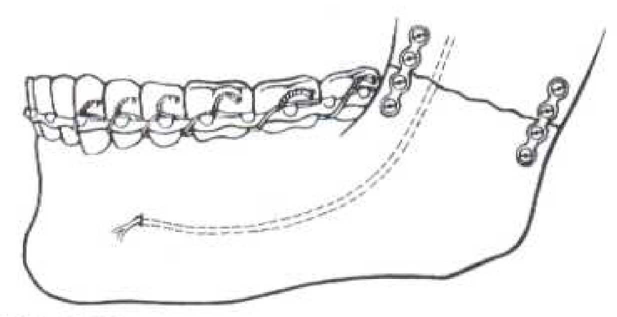


FIG. 5-232

The wound is irrigated, drained, and closed. IMF may now be released.

COMPRESSION PLATE WITH OR WITHOUT A TENSION BAND PLATE

Key Principles	pp. 42, 43, 61, 62
Surgical Approaches	
Intraoral	p. 80
Extraoral	p. 85

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that, for intraoral plate application, a transbuccal approach for drilling and screw application is necessary. Exposure is difficult because of the marked posterior position of the fracture.

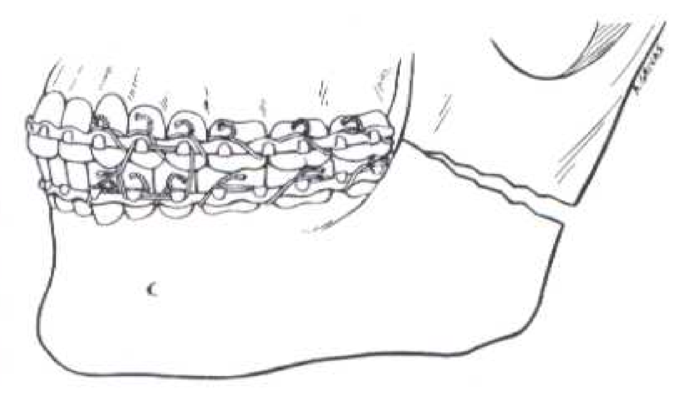


FIG. 5-233

Reduction is carried out manually or with a bone-holding clamp. This is generally accomplished by grasping the proximal fragment and pulling it into reduction against the anterior fragment.

(Optional) Reduction may be carried out by using wire ligatures prior to plate application, particularly if there is gapping anteriorly, in which case, a tension band wire is placed anteriorly and the plate is placed either centrally or posteriorly.

(Optional) A tension band plate may be placed anteriorly. A four-hole miniplate can be used. This is applied along the anterior portion of the fracture, generally using a four-hole plate. Bicortical screws may be used in the thin bone here as long as care is taken to avoid the inferior alveolar nerve.

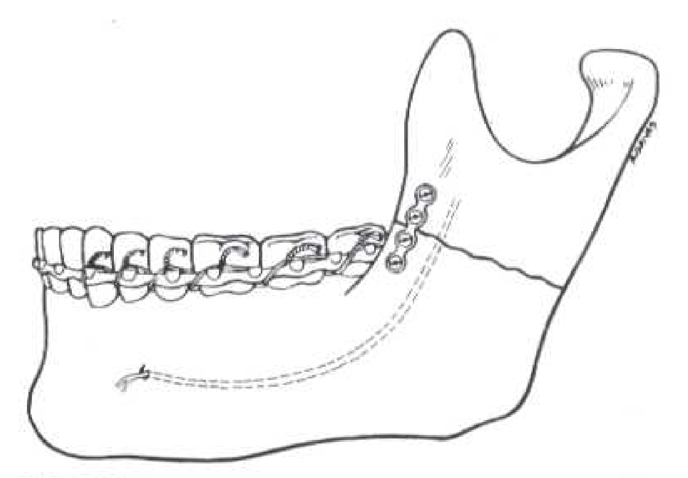


FIG. 5-234

Alternatively, a two- or four-hole compression plate may be applied anteriorly instead of the miniplate. Bicortical screws are used, placing two screws eccentrically away from the fracture for compression. Additional screws, if any, are placed neutrally.

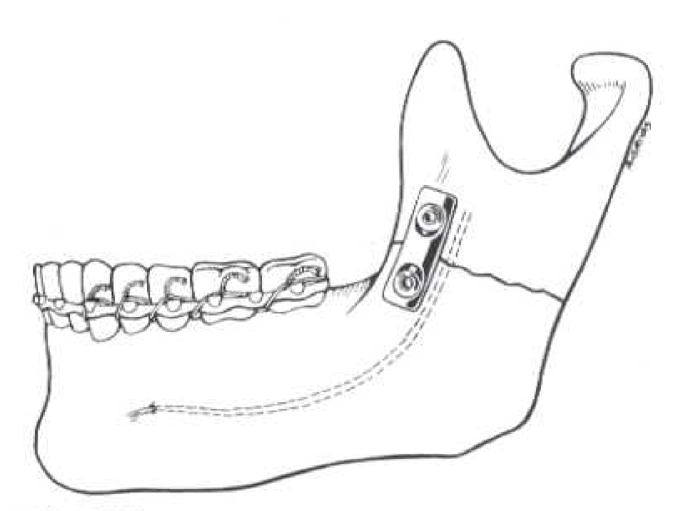


FIG. 5-235

If a single plate is used, it is applied centrally when possible, particularly if no tension band plate or wire is present and there is gapping anteriorly. This increases the stability of the fixation. The plate is carefully bent to the mandibular contour (an intervening template is generally used). The first two bicortical screws are eccentrically placed away from the fracture for compression. The remaining screws are placed neutrally.

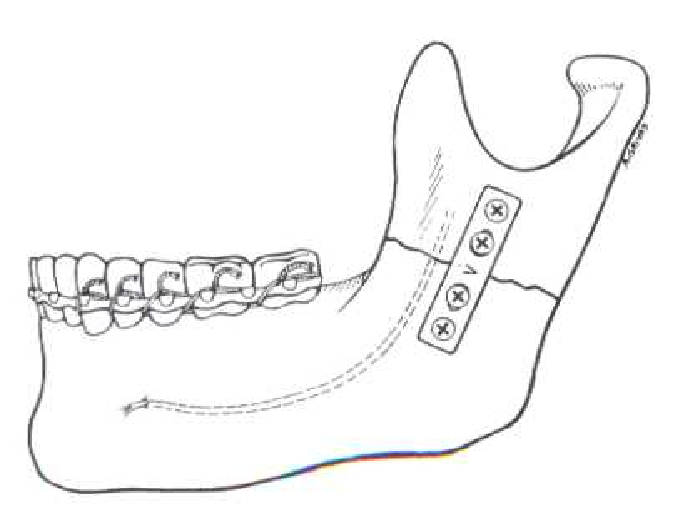


FIG. 5-236

If a tension band plate has been placed anteriorly, the compression plate is placed posteriorly. It is carefully bent to the mandibular contour (an intervening template is generally used). The first two bicortical screws are eccentrically placed away from the fracture for compression. The remaining screws are placed neutrally.

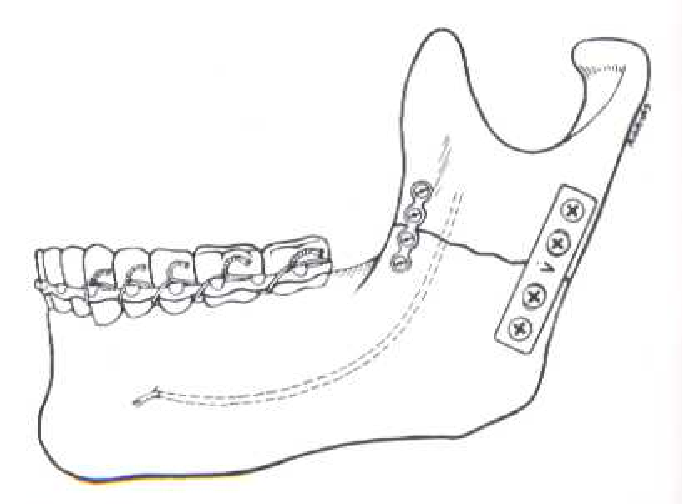


FIG. 5-237

The wound is irrigated, drained, and closed. IMF may now be removed.

MANDIBULAR RECONSTRUCTION PLATE WITH OR WITHOUT A TENSION BAND PLATE

Key Principles	pp. 46, 68 (61, 62)
Surgical Approaches	
Intraoral	p. 80
Extraoral	p. 85

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that for intraoral plate application, a transbuccal approach for drilling and screw application is necessary. Exposure is difficult because of the marked posterior position of the fracture.

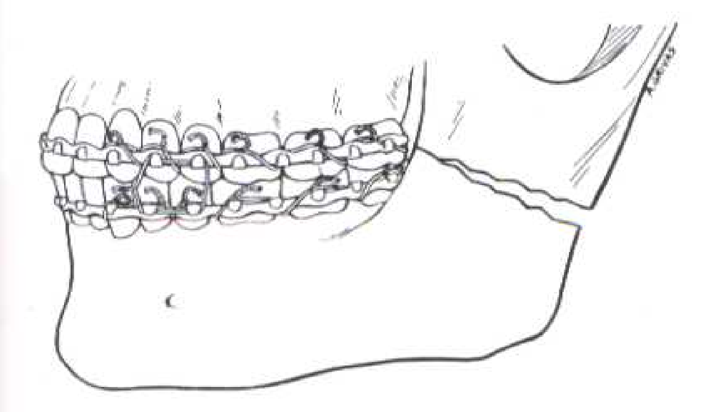


FIG. 5-238

Reduction is carried out manually or with a bone-holding clamp. This is generally accomplished by grasping the proximal fragment and pulling it into reduction against the anterior fragment.

(Optional) Reduction may be carried out using wire ligatures prior to plate application, particularly if there is gapping anteriorly, in which case, a tension band wire is placed anteriorly. The plate is placed posteriorly.

(Optional) A tension band plate may be placed anteriorly. A four-hole miniplate can be used. This is applied along the anterior portion of the fracture, generally using a four-hole plate. Bicortical screws may be used in the thin bone here as long as care is taken to avoid the inferior alveolar nerve.

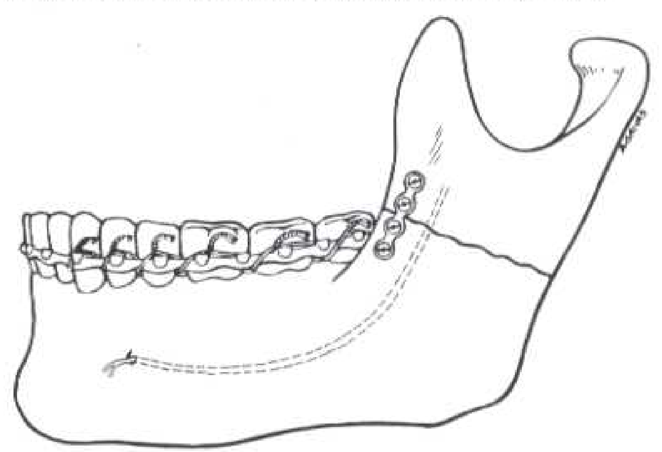


FIG. 5-239

Alternatively, a two- or four-hole compression plate may be applied anteriorly instead of the miniplate. Bicortical screws are used, placing two eccentrically away from the fracture for compression. Additional screws, if any, are placed neutrally.

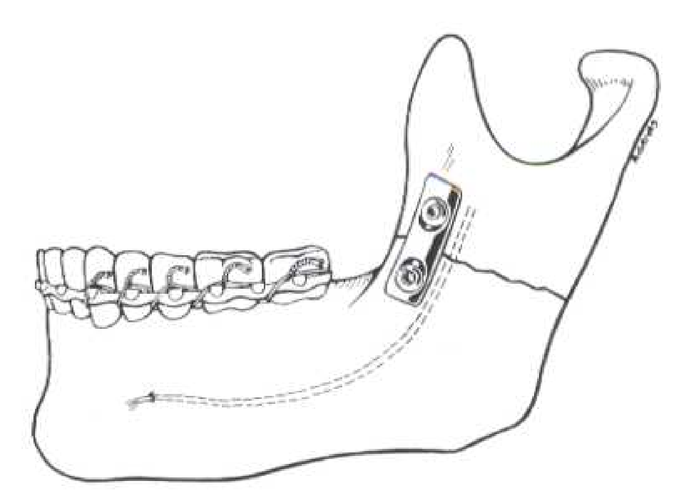


FIG. 5-240

The mandibular reconstruction plate is now applied by using at least a six-hole plate. It is placed posteriorly to allow for placement of at least three or four screws on each side of the fracture. The plate provides enough stabilization so that it can be placed posteriorly in the absence of a tension band.

A template is bent to the mandibular contour. The plate is carefully bent to match the template and, ultimately, the mandible. Note that bending can be difficult, and prebent plates may be helpful.

If some form of tension band has been placed, the first two bicortical screws are placed eccentrically away from the fracture to compress the fragments together. Remaining bicortical screws are placed neutrally.

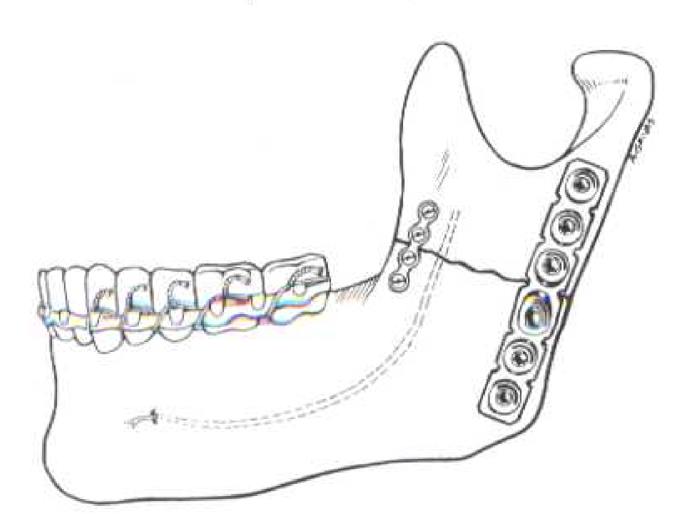


FIG. 5-241

If only the mandibular reconstruction plate is used without anterior fixation, all bicortical screws should be placed neutrally to avoid distraction of the anterior portion of the fracture. Care is taken to avoid injury to the inferior alveolar nerve.

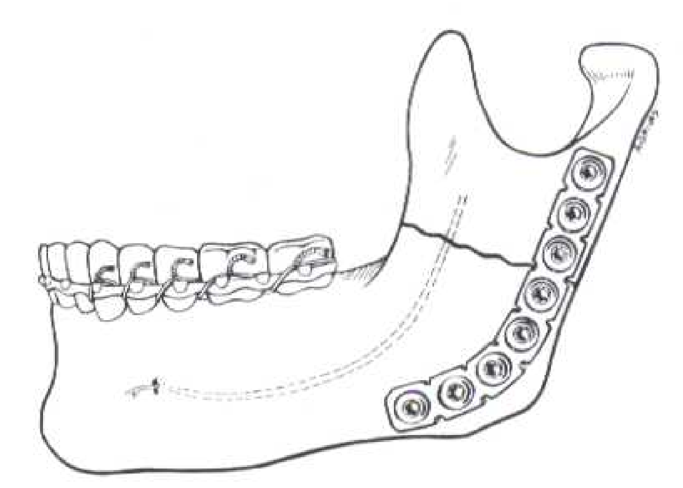


FIG. 5-242

The wound is irrigated, drained, and closed. IMF may now be removed.

CHAPTER 9

Ramus: Vertical Fractures (Dentulous or Edentulous)

An arch bar cannot serve as a tension band in this region because the fracture is behind the dentition. Therefore, distinction is not made between the dentulous and the edentulous mandible. However, the use of intraoperative IMF is still recommended to maintain the proper occlusal relationship. Note also that the mandibular ramus is thin and difficult to access. Finally, it should be noted that a true vertical ramus fracture separates the subcondylar and angle region from the remaining mandible. If the coronoid is separated, it is a coronoid process fracture, and if the fracture passes through the notch and posteriorly above the angle, it is actually a low subcondylar fracture.

MINIPLATES

Key Principles	pp. 42, 61
Surgical Approaches	
Intraoral	p. 80
Extraoral	p. 85

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that, for intraoral plate application, a transbuccal approach for drilling and screw application is necessary. Exposure is difficult because of the marked posterior position of the fracture.

Reduction is carried out manually or with a bone-holding clamp. This is generally accomplished by grasping the proximal fragment and pulling it into reduction against the anterior fragment. It is important to maintain the condylar position in the glenoid fossa.

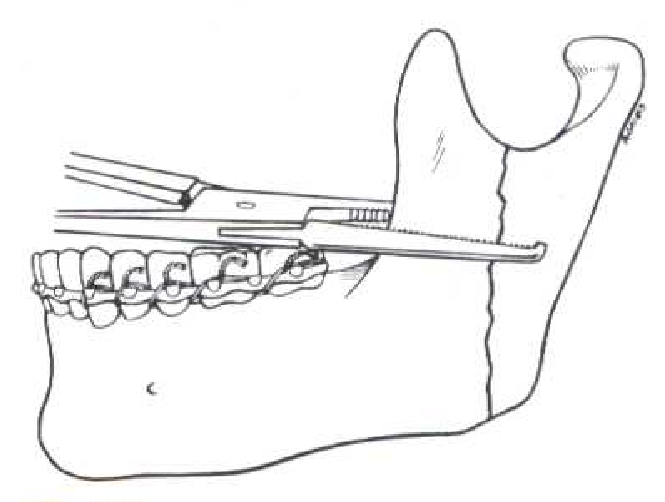


FIG. 5-243

An appropriate miniplate is selected and bent, positioning it above the antilingular prominence. At least a four-hole plate is used. Plate application is completed using either monocortical or bicortical screws; these are placed sequentially. Bicortical screws can be safely used here and add strength to the fixation.

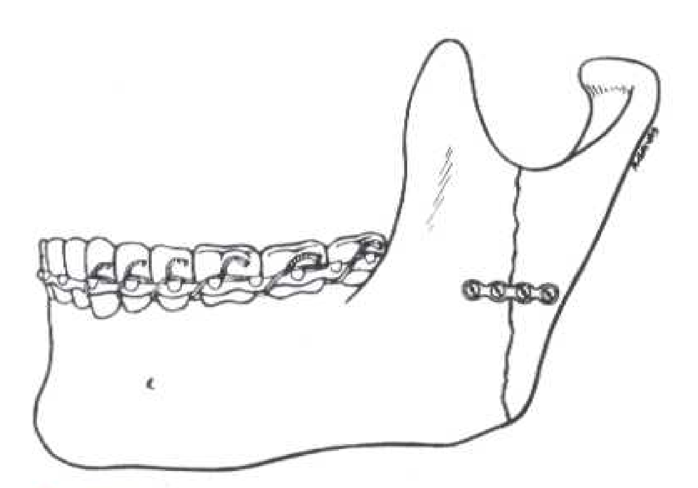


FIG. 5-244

A second miniplate is selected and bent, positioning it below the antilingular prominence. Monocortical screws are placed, using at least two screws on each side of the fracture. If the plate is placed so that it is clearly below the inferior alveolar nerve, then bicortical screws may be used.

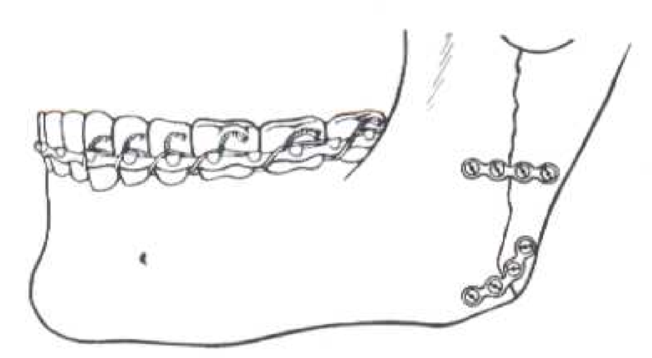


FIG. 5-245

(Optional) If there is enough access, the first miniplate may be placed high enough to allow placement of both miniplates above the antilingular prominence.

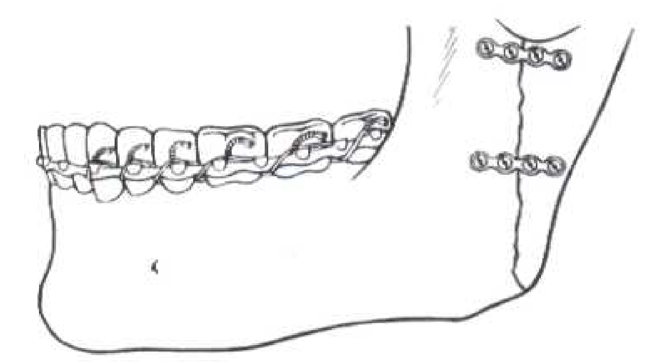


FIG. 5-246

The wound is irrigated, drained, and closed. IMF may now be removed.

TENSION BAND PLATE AND COMPRESSION PLATE

Key Principles	pp. 42, 43, 61, 62
Surgical Approaches	
Intraoral	p. 80
Extraoral	p. 85

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that for intraoral plate application, a transbuccal approach for drilling and screw application is necessary. Exposure is difficult because of the marked posterior position of the fracture.

Reduction is carried out manually or with a bone-holding clamp. This is generally accomplished by grasping the proximal fragment and pulling it into reduction against the anterior fragment. It is important to maintain the condylar position in the glenoid fossa.

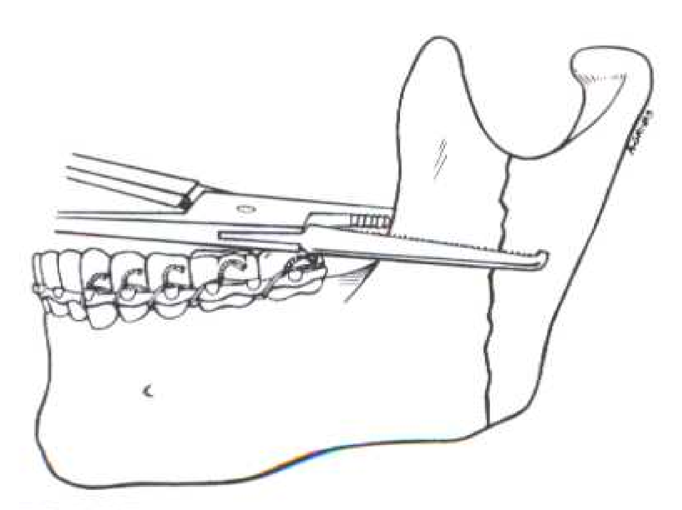


FIG. 5-247

(Option 1) An appropriate miniplate is selected and bent, positioning it above the antilingular prominence, using at least a four-hole plate.

Plate application is completed by using either monocortical or bicortical screws; these are placed sequentially. Bicortical screws can be safely used here and add strength to the fixation.

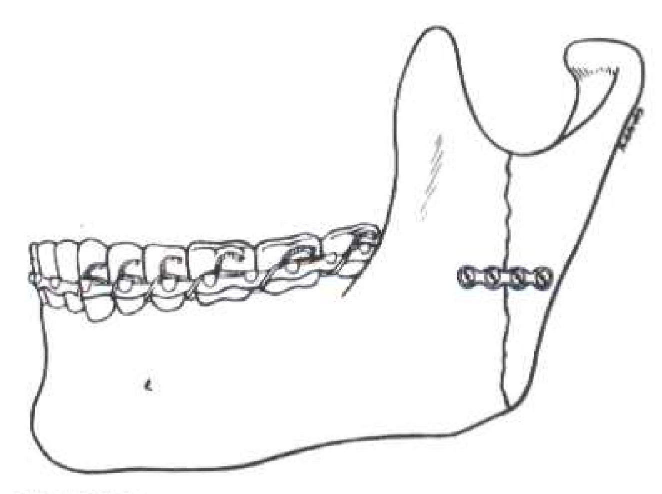


FIG. 5-248

(Option 2) A compression plate may be placed superiorly across the fracture so long as it is placed above the level of the lingula. A template is bent, and the plate is bent to match the template and then the mandible. The plate is held in position, and two bicortical compression screws are eccentrically placed to produce compression across the fracture. If a four-hole plate has been used, the remaining bicortical screws are placed neutrally.

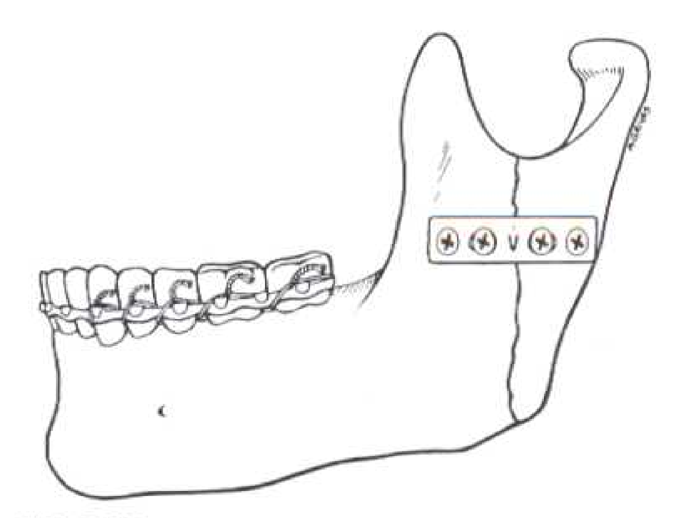


FIG. 5-249

A compression plate is now positioned across the fracture site below the level of the inferior alveolar nerve. At least two holes must be placed behind the fracture, although three are preferable in the thin bone. A template is generally bent to the mandibular contour, and the plate is then bent to match the shape of the template and, ultimately, the bone.

The plate is then positioned, held in place, and applied. The first two bicortical screws are placed eccentrically away from the fracture to produce compression because a tension band plate has been applied. The remaining bicortical screws are placed neutrally.

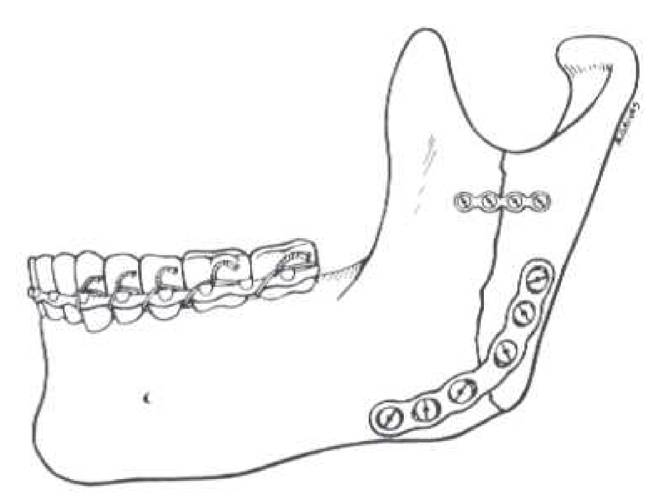


FIG. 5-250

The wound is irrigated, drained, and closed. IMF may now be removed.

MANDIBULAR RECONSTRUCTION PLATE WITH OR WITHOUT A TENSION BAND PLATE

Key Principles	pp. 46, 68 (61, 62)
Surgical Approaches	
Intraoral	p. 80
Extraoral	p. 85

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that, for intraoral plate application, a transbuccal approach for drilling and screw application is necessary. Exposure is difficult because of the marked posterior position of the fracture.

Reduction is carried out manually or with a bone-holding clamp. This is generally accomplished by grasping the proximal fragment and pulling it into reduction against the anterior fragment. It is important to maintain the condylar position in the glenoid fossa.

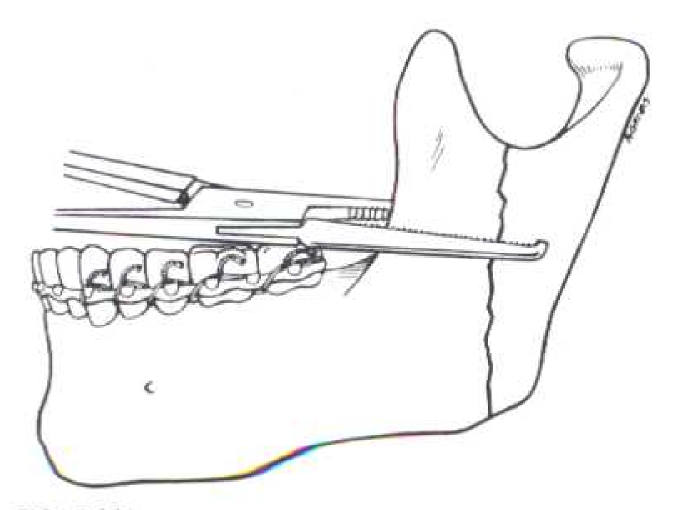


FIG. 5-251

(Optional) An appropriate miniplate is selected and bent, positioning it above the antilingular prominence. At least a four-hole plate is used. Plate application is completed, using either monocortical or bicortical screws; these are placed sequentially. Bicortical screws can be safely used here and add strength to the fixation.

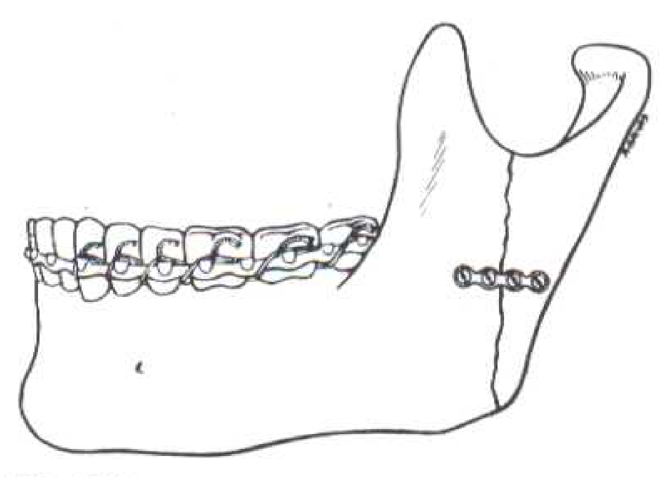


FIG. 5-252

(Optional) A compression plate may be placed superiorly across the fracture, so long as it is placed above the level of the lingula. A template is bent, and the plate is bent to match the template and then the mandible. The plate is held in position, and two bicortical compression screws are eccentrically placed to produce compression across the fracture. If a four-hole plate has been used, the remaining bicortical screws are placed neutrally.

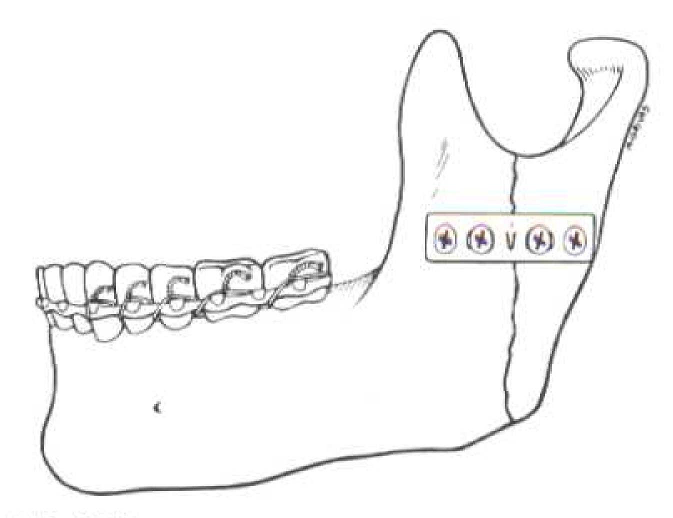


FIG. 5-253

The mandibular reconstruction plate is now applied by using at least a six-hole plate. It is placed posteriorly to allow for placement of at least three or four screws on each side of the fracture. The plate provides enough stabilization so that it can be placed posteriorly in the absence of a tension band. A template is bent to the mandibular contour. The plate is carefully bent to match the template and, ultimately, the mandible. Note that bending can be difficult, and prebent plates may be helpful.

If some form of tension band has been placed, the first two bicortical screws are placed eccentrically away from the fracture to compress the fragments together. The remaining bicortical screws are placed neutrally.

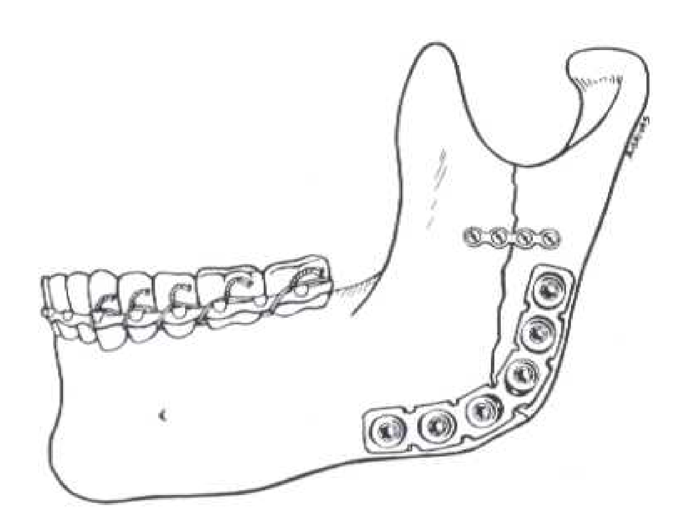


FIG. 5-254

If only the mandibular reconstruction plate is used, all bicortical screws are placed neutrally. Care is taken to avoid injury to the inferior alveolar nerve.

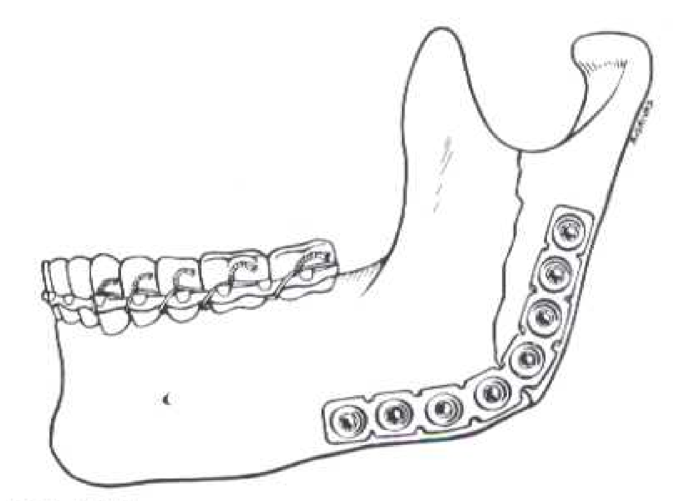


FIG. 5-255

The wound is irrigated, drained, and closed. IMF may now be removed.

CHAPTER 10

Subcondylar Fractures

The frequency with which subcondylar fractures are opened varies dramatically, depending on the philosophy of the surgeon and the area in which he or she practices. Our atlas illustrates the techniques involved. Whether to open and whether to use plates, however, are the surgeon's decisions. Intraoperative IMF is recommended to ensure the maintenance of the proper occlusal relationship.

MINIPLATE

Key Principles	p. 61
Surgical Approaches	
Intraoral	p. 80
Extraoral	p. 85

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that, for intraoral plate application, a transbuccal approach for drilling and screw application is necessary. Intraoral exposure and plate application are technically difficult. The fracture fragments are manually reduced.

(Optional) A wire ligature may be applied to stabilize the fragments prior to plating. The plate is bent and then applied to the superior (condylar) fragment, using at least two screws, usually bicortical.

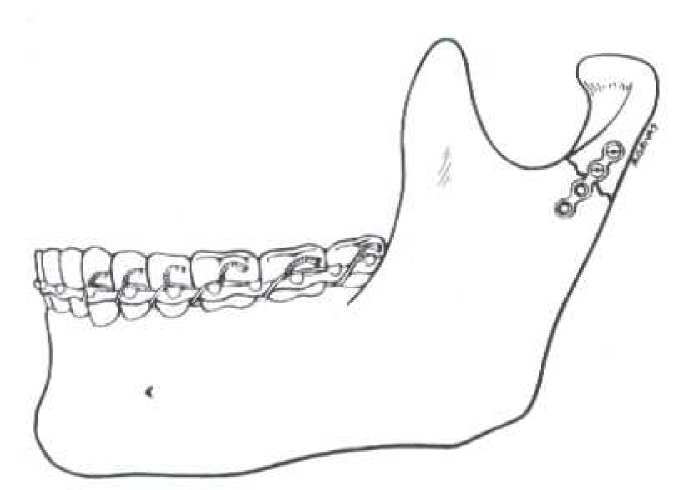


FIG. 5-256

With the fracture reduced, the screws are then placed in the inferior fragment, using at least two screws. Bicortical screws may be used here. (If a wire has been used, it may be left in place or removed.)

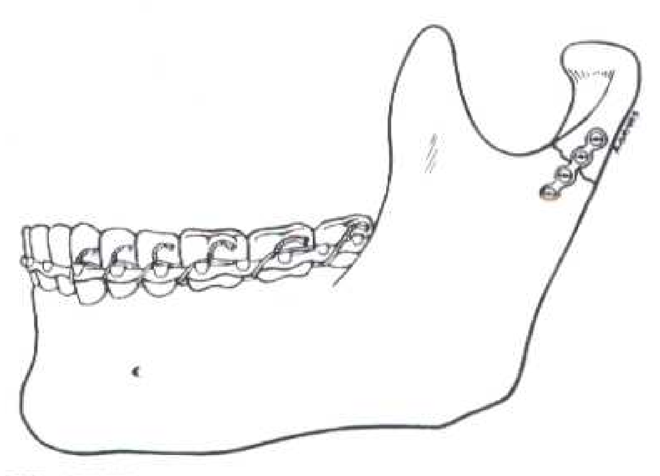


FIG. 5-257

The wound is irrigated, drained, and closed. IMF may now be released.

COMPRESSION PLATE

Key Principles	p. 62
Surgical Approaches	
Intraoral	p. 80
Extraoral	p. 85

***NOTE:** A compression plate technique is not advised if the plate extends superiorly onto the condylar process.*

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that, for intraoral plate application, a transbuccal approach for drilling and screw application is necessary. Intraoral exposure and plate application are technically difficult. The fracture fragments are manually reduced. A wire ligature may be applied to stabilize the fragments prior to plating.

A template is positioned over the reduced fragments, and the plate is bent to match the template and then the bone. The first bicortical compression screw is placed eccentrically away from the fracture in the condylar fragment.

The second compression screw is placed eccentrically in the inferior fragment, both screws are tightened, and compression is produced.

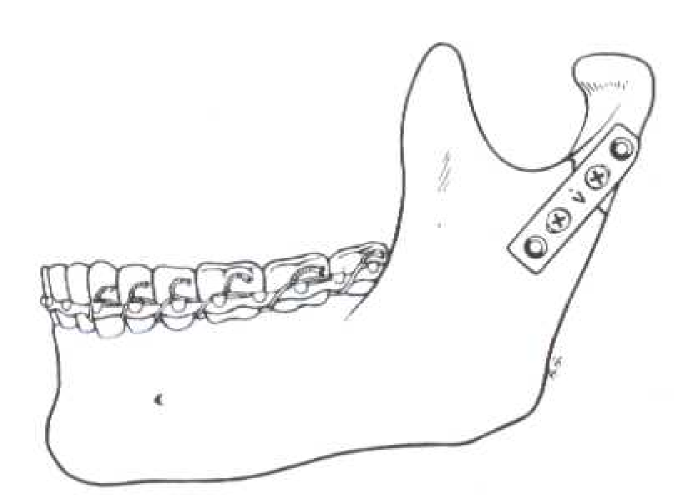


FIG. 5-258

Two remaining bicortical screws are placed neutrally. (If a wire has been used, it may be left in place or removed.)

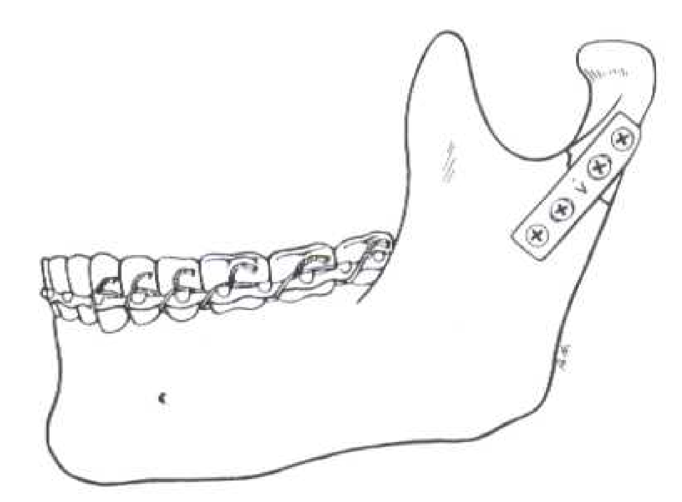


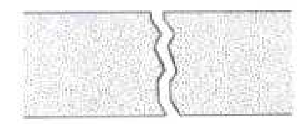
FIG. 5-259

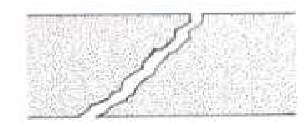
The wound is irrigated, drained, and closed. IMF may now be released.

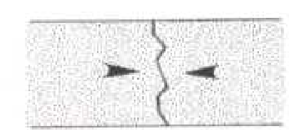
CHAPTER 11

Oblique (Overlapping) Fractures: Overlapping Fragments

1. Whenever fragments overlap so that the edges of the fragments cannot abut against one another, axial compression works to cause overlap and displacement of the fragments, rather than resulting in reduction, realignment, and interfragmentary compression and stability. A lag screw technique is therefore used to compress the fragments together in proper position.







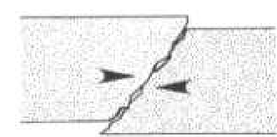


FIG. 5-260

2. The diameter of the gliding hole should be the diameter of the screw thread so that the screw thread does not catch, but it holds the bone in position without excessive play or wobble. The threaded hole should be the size of the screw shaft. The screw sizes vary from system to system; therefore, the reader must be familiar with the specifications of the system being used.

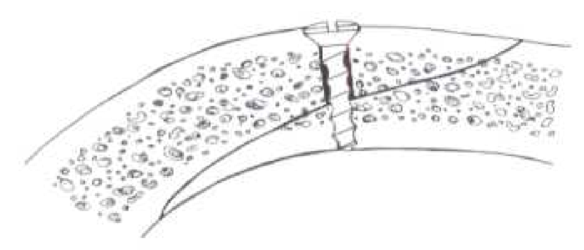


FIG. 5-261

3. Several lag screws generally are adequate to reduce a fracture.

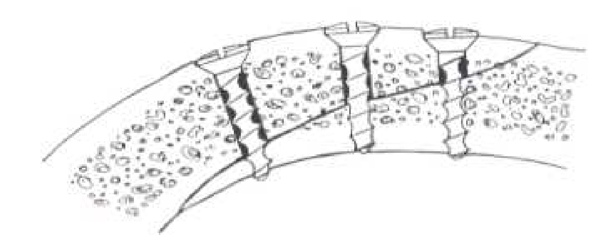


FIG. 5-262

However, if desired and feasible or if the amount of overlapping bone is inadequate to accept more than one or two lag screws, a plate should be used for added strength of repair.

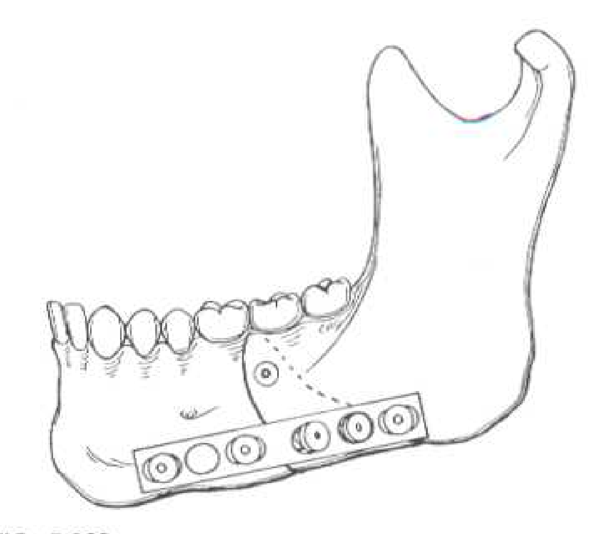


FIG. 5-263

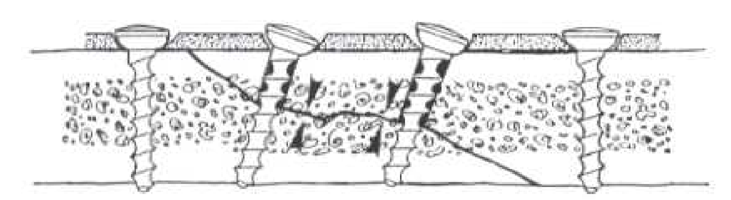


FIG. 5-264

The following caveats are important.

1. Any screw placed through overlapping fragments (whether through a plate or not) must be placed as a lag screw, or it will cause distraction of the fragments.
2. When lag screws and nonlag screws are placed through a plate, the lag screws should be placed first to compress the fracture fragments together.
3. Any screws placed through the plate that are not lag screws (i.e., they pass through only one fragment) must be placed neutrally, to avoid pressure on the lag screws.

LAG SCREW

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that, for fractures behind the midbody of the mandible, transbuccal placement of screws is necessary, if an intraoral approach is used.

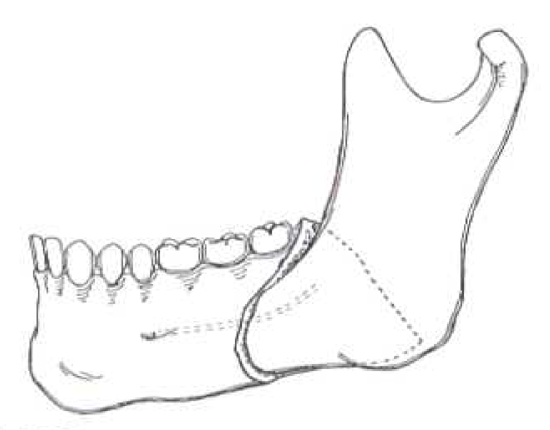


FIG. 5-265

The overlapping fragments are reduced and compressed together with modified towel clips or bone clamps. The use of reduction forceps is not advised because the forceps tend to cause overriding of the fragments.

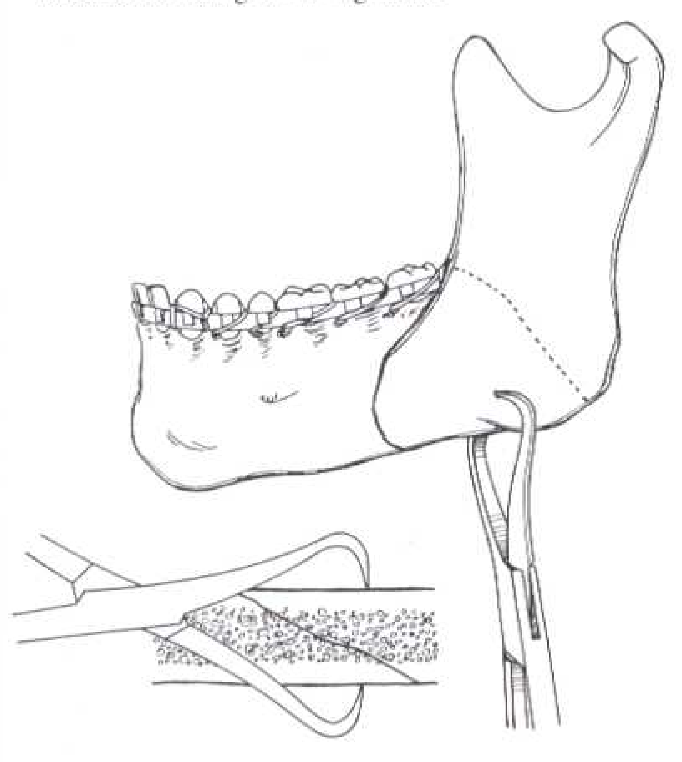


FIG. 5-266

The first hole is drilled with a drill bit that is the size of the screw to be used (frequently, a 2.7-mm drill bit). Be sure to stop before entering the second fragment.

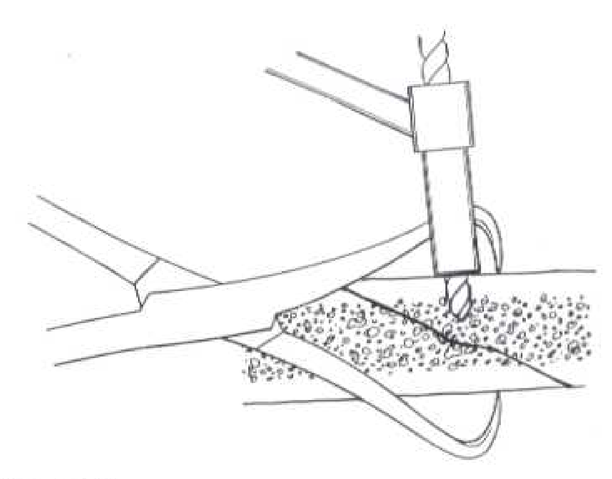


FIG. 5-267

If available, a drill sleeve is placed into the hole in the first cortex. Using a drill bit the size of the screw shaft (frequently, 2.0 mm), a hole is drilled through the second fragment.

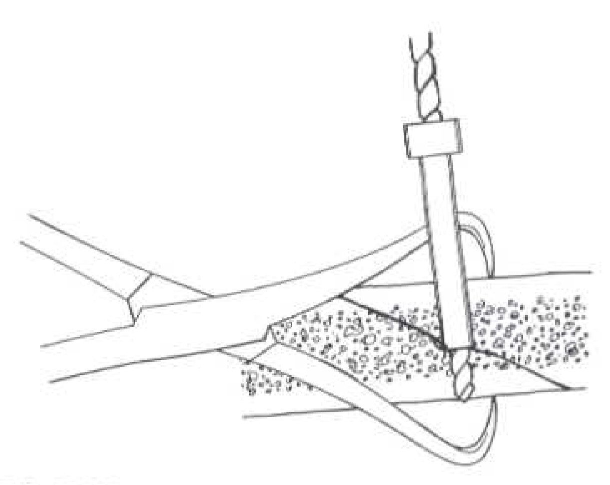


FIG. 5-268

A countersink is used to enlarge the opening of the proximal drill hole for better seating of the screw head. The depth of the hole is measured with a depth gauge. Make certain that both fragments are included. When a nonself-tapping system is used, the hole (in the second cortex) is tapped with an appropriate tap (frequently, 2.7 mm).

An appropriate screw (frequently, 2.7 mm) (length as previously measured) is placed and tightened.

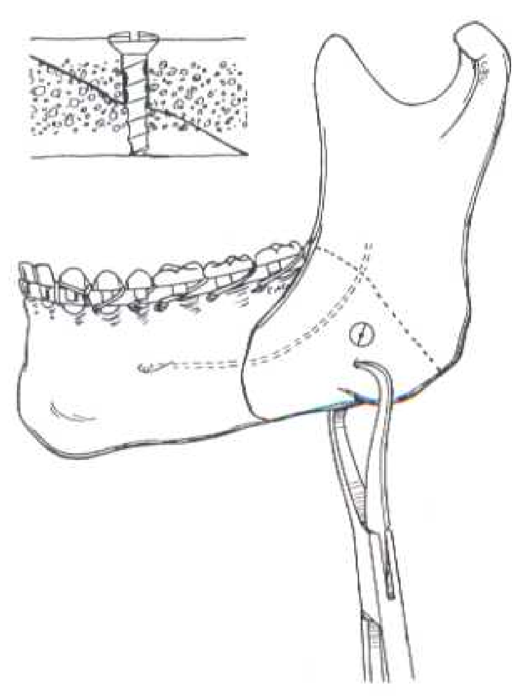


FIG. 5-269

A second screw is placed generally at a slightly different angle across the fracture by repeating the same technique for lag screw placement. The bone clamp is then removed.

In the edentulous mandible, when mandibular height is adequate, one or two lag screws can be placed above the inferior alveolar nerve.

A third lag screw is placed, and if there is enough bone available, a fourth.

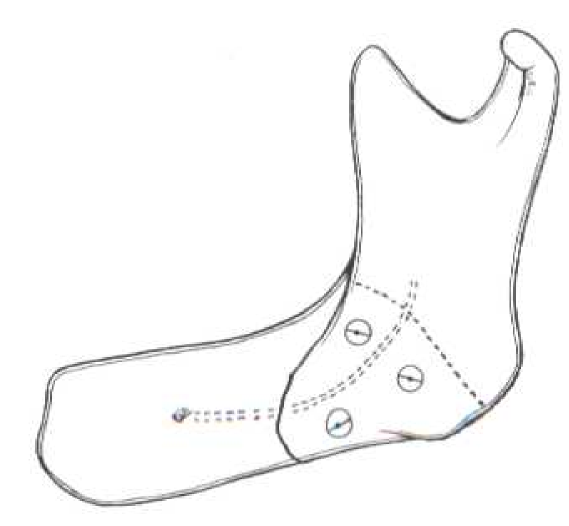


FIG. 5-270

The wound is irrigated, drained, and closed. IMF may now be released.

LAG SCREW AND PLATE

***NOTE:** When a lag screw is placed through a plate hole, the screw is generally not perpendicular to the plate. The degree of angulation possible without jeopardizing stability varies depending on the plate-hole design. Because designs are modified frequently, the reader is urged to obtain these specifications from the manufacturer.*

Occlusion is first established by the appropriate means. The fracture is exposed, either intraorally or extraorally. Note that, for fractures behind the midbody of the mandible, transbuccal placement of screws is necessary if an intraoral approach is used. The overlapping fragments are reduced and compressed together with modified towel clips or bone clamps. The position for plate placement is determined.

If adequate bone is available, a lag screw may be placed above or below the plate to stabilize and compress the fragments prior to plate placement. If so, this is accomplished by following the steps in the earlier section.

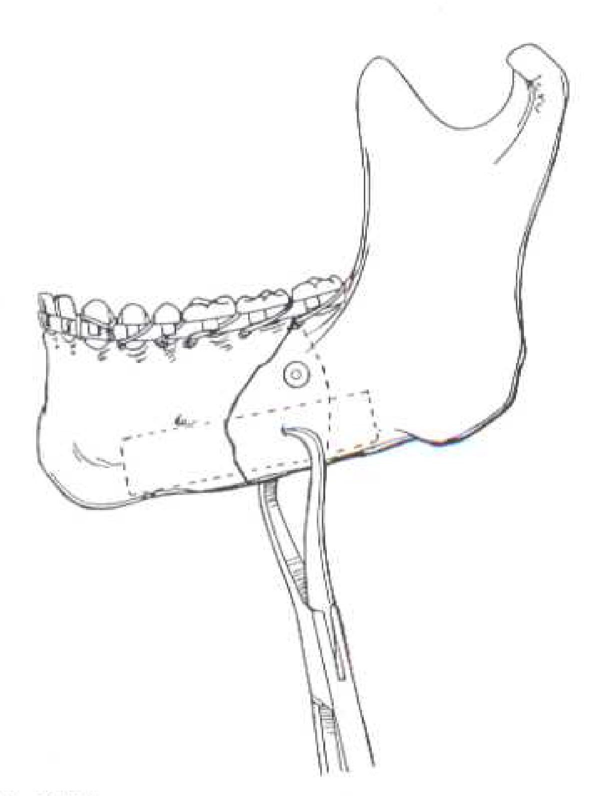


FIG. 5-271

When the area of bony overlap is limited, the plate is positioned so that at least one screw hole overlies the overlapping area and there are at least two screws in each fragment. The first hole is drilled through the plate hole, using the direction and angle appropriate for the overlapping area. A drill bit that is the size of the screw thread is used. Be sure to stop before entering the second fragment. If available, a drill sleeve is placed into the hole. The second cortex is now drilled, using a drill bit the size of the screw shaft. The depth of the hole is measured with a depth gauge. Make certain that both fragments are included. When a nonself-tapping system is used, the hole (the second cortex) is tapped with a tap the size of the screw thread.

A screw of the appropriate size (length as previously measured) is placed and tightened.

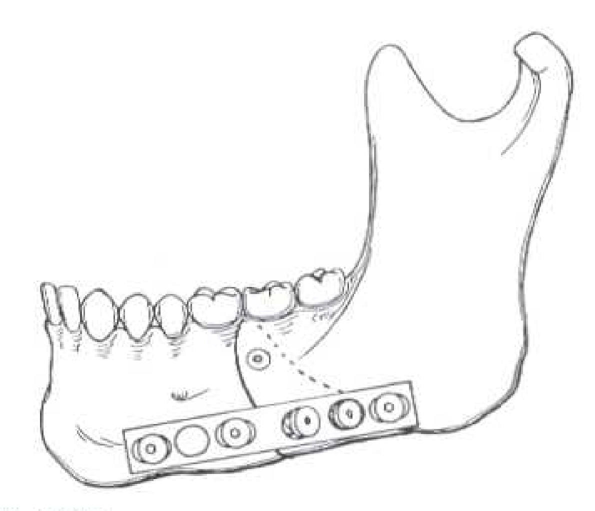


FIG. 5-272

If another plate hole overlies the overlapping fragments, then another lag screw is placed, repeating these steps.

The remaining screws are placed neutrally in the nonoverlapping areas.

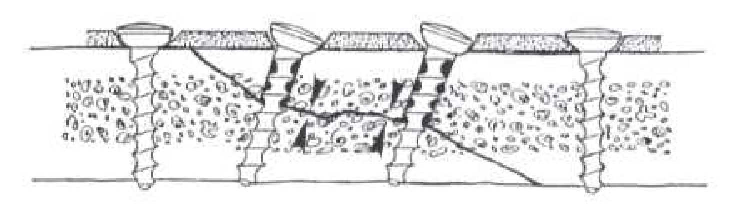


FIG. 5-273

The wound is irrigated, drained, and closed. IMF may now be released.

CHAPTER 12

Comminuted Fractures

The variety of possible fractures and fracture combinations is large. Therefore, a few representative samples are shown in this section illustrating some of the repair techniques. The reader should be able to extrapolate from these examples for application to other situations that may be encountered. Strict adherence to the principles of rigid fixation it is hoped should minimize complications and increase the likelihood of a successful repair and satisfactory outcome.

Complex comminuted fractures may require the combination of multiple techniques, many of which have been previously illustrated. These techniques are not repeated in this section.

SMALL AREA OF COMMINUTION

As in other situations, occlusion is first established to whatever extent is possible and by whatever means is most suitable.

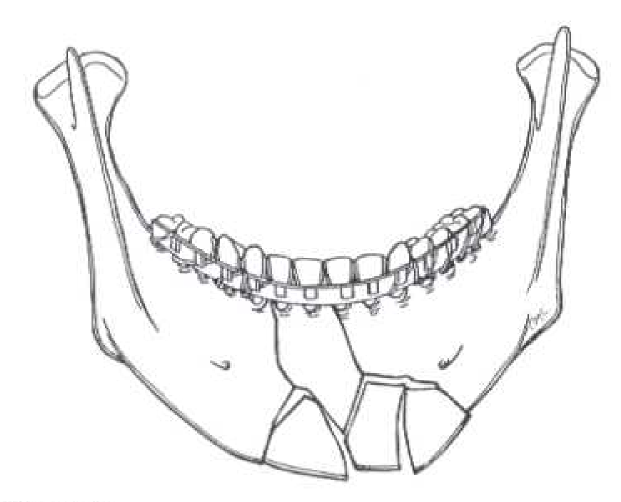


FIG. 5-274

The fractured area is exposed either intraorally or extraorally. For extensive injuries, the extraoral approach generally provides greater access and minimizes the likelihood of inferior alveolar nerve injury.

Small fragments may be compressed together between larger mandibular segments either with a long compression plate or a mandibular reconstruction plate. Compression screws are applied on either side of the comminuted area, generally in the holes closest to this area.

The remaining screws in the two solid fragments are placed neutrally.

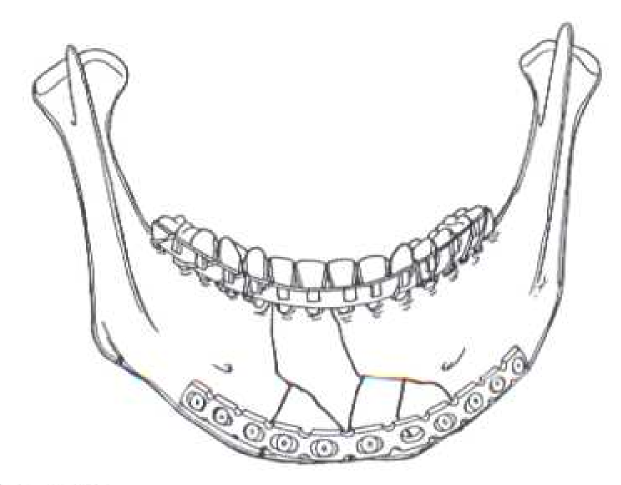


FIG. 5-275

Because areas of comminution provide little structural support, it is wise to consider these defect areas. Therefore, whenever possible, at least three screws should be placed in the supporting fragments on either side of such an area. This is even more important when compression is not possible.

Small fragments may be fixed directly to the plate with neutrally placed screws. This increases the stability of the fixation. However, when properly compressed between the surrounding solid segments, this may not be necessary.

The wound is irrigated, drained, and closed. IMF may now be released if stability is satisfactory.

LARGE AREA OF COMMINUTION

As in other situations, occlusion is first established to whatever extent is possible and by whatever means is most suitable. The fractured area is exposed, either intraorally or extraorally. For extensive injuries, the extraoral approach generally provides greater access and minimizes the likelihood of inferior alveolar nerve injury.

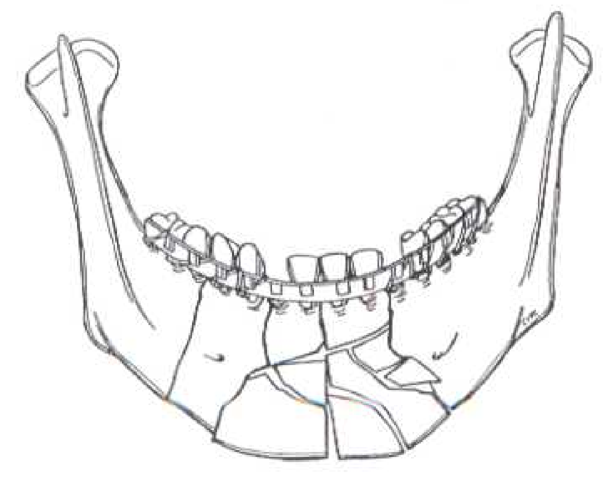


FIG. 5-276

An area of significant comminution provides little structural integrity for mandibular support and should be viewed as a defect area. This should be bridged with a mandibular reconstruction plate with at least three or four screws in the solid bone on each side of the comminuted area.

Small fragments may be fixed directly to the plate with neutrally placed screws. This increases the stability of the fixation. However, if they can be compressed between the surrounding solid segments, this may not be necessary.

Small fragments are sometimes wired or fixed with miniplates to neighboring fragments.

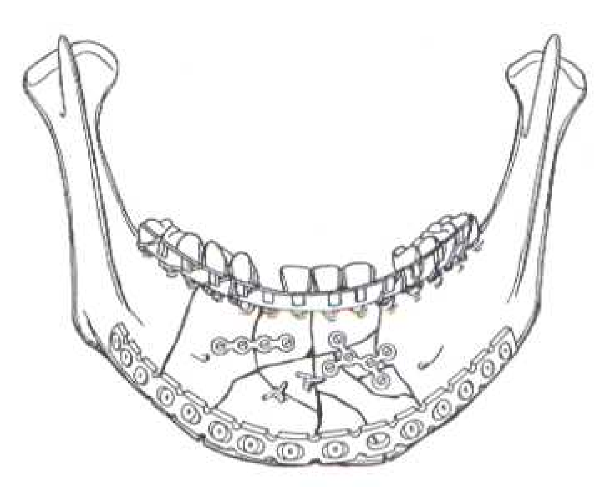


FIG. 5-277

Areas of bone loss may be grafted primarily or secondarily (see Unit 4).

The wound is irrigated, drained, and closed. IMF may be released if stability is satisfactory.

UNIT VI

Mandible: Defects

UNIT OUTLINE

CHAPTER 1

Traumatic Defects

The most difficult aspect of repairing mandibular defects is that it is hard to reestablish the precise occlusal relationship when segments of bone have been lost. Nonetheless, every attempt should be made to reestablish the premorbid occlusion by using arch bars and wires. Loose teeth should not be extracted until after rigid fixation has been accomplished because they may provide the only frame of reference available.

Rigid fixation allows for the primary reconstitution of the hard structure architecture, whether soft tissue is present or absent, and whether it is repaired primarily or secondarily.

TECHNIQUE

Occlusion is reestablished as well as possible. The bone fragments are manually positioned as closely as possible to what is believed to be the premorbid position. They are held in this position while a template is positioned and bent to match the defect so that it overlaps both remaining solid fragments. Smaller floating fragments in the defect are unimportant at this time.

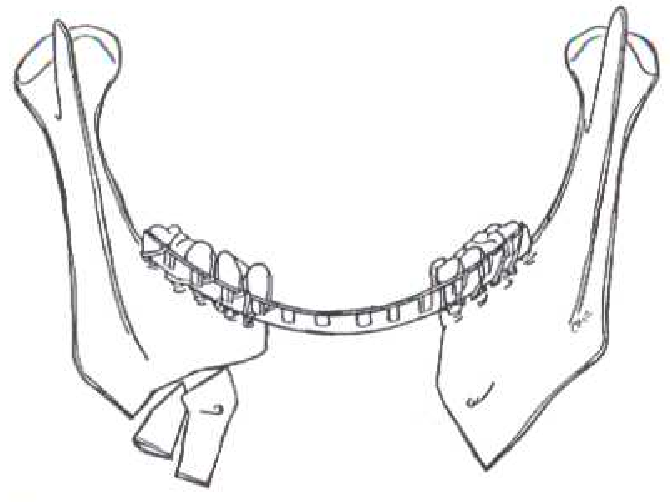


FIG. 6-1

A mandibular reconstruction plate is bent to match the template. It is important to plan for at least three screws through the plate into the solid remaining bone on each side of the defect. However, four or even five screws on each side will increase the stability of the fixation.

The wound is débrided and cleansed, and the plate is applied along the inferior border of the mandible, placing all screws neutrally through both cortices. In this situation, it is recommended that a 2.7-mm or larger screw be used.



FIG. 6-2

Small devitalized bone fragments should be débrided. Larger fragments and fragments with periosteum still attached should be fixed to neighboring bone fragments if adjacent. Otherwise, they can be fixed directly to the plate. Fragments that cannot be stabilized should be débrided.

(Optional) Soft or hard tissue may be brought in to repair any defective area, although whether to do so acutely and the type of tissue transfer (i.e., soft tissue *versus* soft and hard tissue and pedicled *versus* free flaps) remain controversial. It is beyond the scope of this atlas.

Closure to whatever extent is feasible is completed. If satisfactory rigid fixation has been accomplished, there is no need to leave the patient in intermaxillary fixation (IMF). In fact, removing IMF is preferable.

CHAPTER 2

Oncologic Defects

Whether performing a mandibular osteotomy for access (such as the mandibular swing operation) or resecting a significant portion of the mandible as part of the tumor resection, the basic principle is the same. That is, a portion of mandible has been resected (in the swing operation, it may be as little as the width of the saw blade), and a strong fixation appliance, generally a mandibular reconstruction plate (MRP), is indicated if rigid fixation is to be accomplished. (Compression fixation after osteotomy may be ill-advised because it alters the bony relationship by compressing across a gap, albeit a small gap, and this also has the potential of stressing the temporomandibular joints.) Many approaches have been advocated for stabilization of the remaining mandibular segments. The approach believed by the authors to be the most dependable is that of preapplication of the MRP. This technique brings the bone segments into the precise relationship that they were in prior to the ablative surgery. Condylar position is thereby maintained, and when teeth are present, occlusion is also maintained. A stable fixation, i.e., using at least three or four screws on each side of the defect (osteotomy) obviates the need for arch bars and IMF.

Finally, a stable fixation, such as that achieved by using more than four screws on each side of the defect, decreases the likelihood of failure in the presence of previously radiated or yet to be radiated bone. When radiation has been given or is contemplated, the use of a titanium hollow screw reconstruction plate (THRP) is recommended.

Most resections do not include the condyle. Therefore, most can be repaired by using a standard mandibular reconstruction plate, although occasionally, only two screws can be placed into the small superior remnant. In this situation, the THRP provides the most stable plate repair.

When the condyle is resected, several options for repair are available.

1. The best selection is probably the free vascularized bone flap.
2. Plates with condylar heads attached are available. Applying them may seem easy, particularly because they are only screwed into the bone on one side; however, occlusal shifts and glenoid fossa erosion may result. They are currently used infrequently, and no specific discussion of this technique is presented.
3. A costochondral graft may be fixed to the upper portion of a plate. If this technique is selected, it is wise to use a THRP.

PLATE REPAIR

NOTE: *This section pertains to primary rigid fixation of the osteotomy or defect with a plate only. No bone graft or bone flap is performed with this approach.*

Radical neck dissection has been completed, and the area of resection has been defined. (For osteotomies, the width of the saw blade will be considered to be the resection area.)

(Optional) When resecting a large area, the outer cortex along the inferior border may be thinned with a burr to one plate depth. This allows positioning of the plate into this defect rather than having it overlie the outer cortex. The final plate position after resection and reconstruction thus leaves the plate in an area previously occupied by the bone in the resected area, rather than lateral to it. This will decrease the stress on the overlying skin flap.



FIG. 6-3

A template is bent to fit over the outer cortex of the mandible inferiorly. Make sure that at least four screw holes (when possible) overlap the solid bone on each side.

The plate is carefully bent to match the template. (When using a THRP, inserts are placed in the holes to prevent distortion during bending.) Final bending is matched directly to the bone. A plate-holding forceps stabilizes the plate to the bone.

Two neutral screws are placed on each side of the planned area of resection. This defines the plate and bone relationship.



FIG. 6-4

These screws are then removed, carefully identifying them, so that, when they are replaced later, each screw is returned to the bone hole in which it had been previously placed. It is also important to mark the plate holes carefully because the plate can be unwittingly fitted to the bone in a different position after the resection has been carried out.

The resection is completed. The oral cavity soft tissue is reconstructed as needed.

(Optional) The plate may simply overlie a primary mucosal repair. However, a flap is frequently used to repair the oral cavity. In this case, the plate may pass over, under, or through the pedicle. When a free myocutaneous flap is used (e.g., the rectus myocutaneous free flap), the muscle may be wrapped around the plate without compromising the blood supply to the flap. Care should be taken to avoid compressing or otherwise damaging the flap vessels when placing the plate. If the plate is tunneled through the muscle pedicle (e.g., when using a pectoralis major myocutaneous flap), a Kelly clamp is carefully passed through the muscle and a 1/2-inch Penrose drain is brought back through. The plate is then passed through the rubber drain. The drain is then removed, leaving the plate comfortably in the surrounding muscle.

The plate is now positioned so that the plate holes overlap the previously used holes in the exact same position. The four screws are replaced into their original holes. This recreates the mandibular contour and condylar positions.

The remaining screws are placed neutrally, thereby completing the fixation.

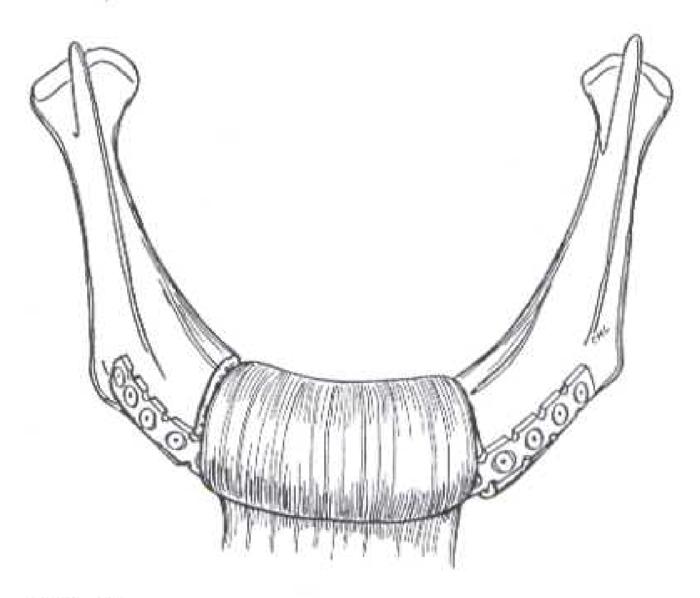


FIG. 6-5

The wound is irrigated, drained, and closed.

BONE FLAP AND PLATE

When a bone flap is used, the bone is revascularized and is therefore living. Therefore, this no longer represents a bony defect. Rather, this functions as two fracture sites. Because the bone is alive, screws can be placed safely in it, and it can also be compressed. Three approaches are therefore possible.

1. The technique described earlier in which the MRP is preapplied prior to the resection can be used. The bone flap can be contoured precisely to the defect. It can be placed into the defect before or after the MRP has been repositioned, depending on the surgeon's preference, and taking care to avoid any injury to its attachment to any soft tissue being used for reconstruction. The preexisting holes can still be utilized, thereby reestablishing the preexisting relationship of the mandibular stumps. Screws are then placed through the plate into the bone flap, thereby fixing the bone flap rigidly to the plate, and thus also fixing it rigidly relative to the surrounding mandibular bone stumps.
2. As an alternative, the precisely contoured bone flap may be fixed to the bone stumps by using compression plates or miniplates. In this approach, the bone flap is designed to replace the resected bone as precisely as possible. The flap is positioned between the stumps, so that the defect is completely bridged. This leaves two sites to repair that are similar to osteotomy sites without a gap. These are then fixed with compression plates, miniplates, or a combination approach, as described in Unit 5. For dependable stabilization, at least two miniplates (if a miniplate technique is used) or at least a six-hole compression plate (if a compression plate technique is used) should be used. For safer stabilization, a miniplate and a compression plate or a MRP may be used.



FIG. 6-6

Note that, using this approach, despite excellent contouring, because a MRP has not been preapplied, the stump positions may be altered. This can change occlusal relationships and condylar positions. In the presence of teeth, it may therefore be advisable to place the patient in IMF during the procedure.

3. The bone flap can be designed to overlap the stumps partially on each end. Lag screws can then be used to fix the flap to the underlying mandibular stumps. This is described in the section on bone grafts.

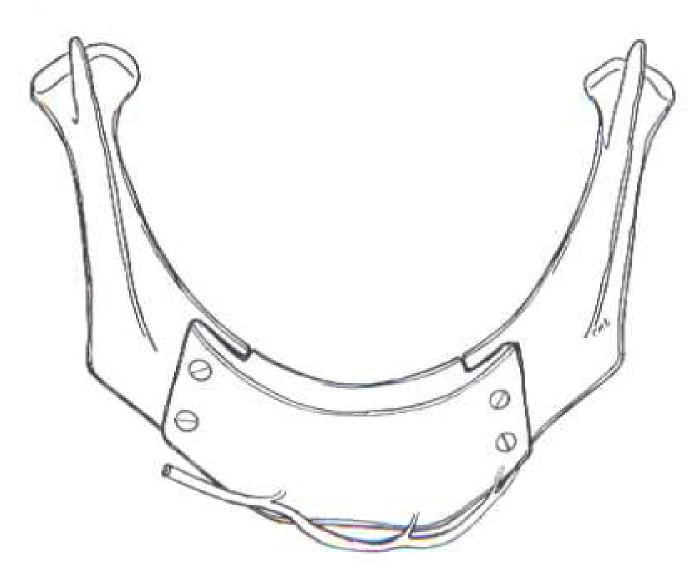


FIG. 6-7

CHAPTER 3

Bone Grafts

Unlike a bone flap, which is vascularized (and therefore alive), a bone graft is deprived of its blood supply when it is harvested, and this blood supply is not reestablished at the time of graft placement (in contradistinction to the bone flap). Therefore, placement of a screw into a cortical bone graft is not recommended, unless the screw is otherwise stabilized (either to underlying living bone or to a THRP) because the likely resorption of some of the bone frequently leads to screw loosening. This will result in a free-floating foreign body with a resultant high likelihood of infection and graft failure. However, if the screw is fixed either to living bone or to a plate (as can be accomplished with the THRP), then rigid stabilization should increase the likelihood of graft revascularization and survival.

The choice of the graft type and donor site is up to the surgeon's discretion. (The reader is referred to Unit 4 for the harvesting technique.) The mandible can be reconstructed by using cancellous bone or a cortical bone graft (usually corticocancellous). The use of trays is not currently recommended by the authors and will not be discussed.

CANCELLOUS BONE

The area to be reconstructed is exposed either intraorally or extraorally. In some cases (e.g., prior tumor resection with primary plate reconstruction), a mandibular reconstruction plate is already in place bridging the defect. In others (e.g., osteomyelitis), the defect area is stabilized and bridged during the same procedure. In this latter situation, the healthy mandibular segments are carefully positioned so that proper occlusion is established (by using IMF) and the ramus and condylar positions are correct. A template is bent, and a MRP is bent, positioned, and applied by using at least three or four neutral screws on each side of the defect.

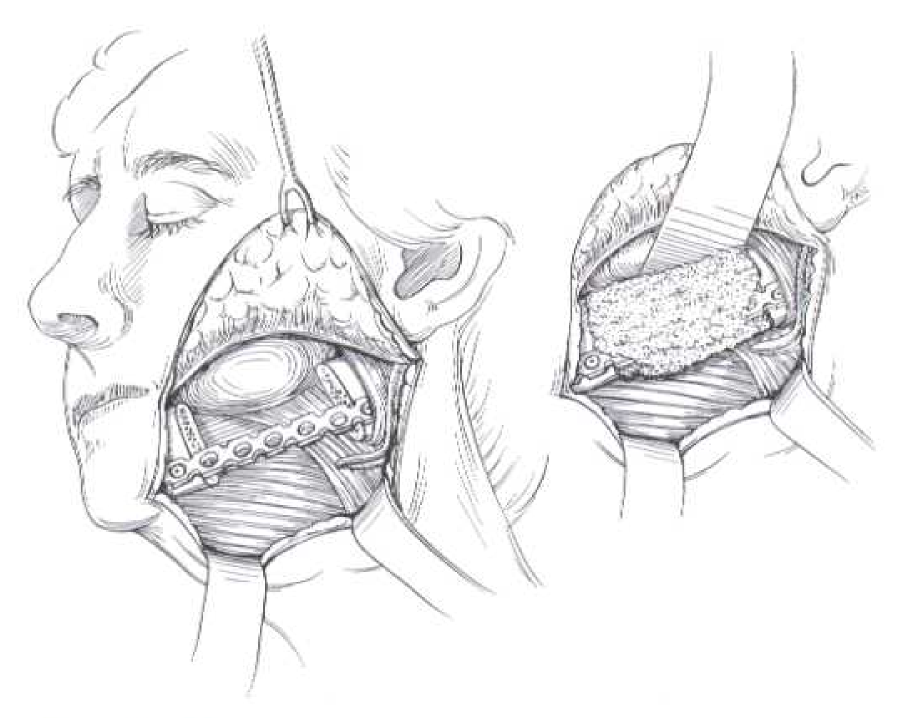


FIG. 6-8A and B

A soft tissue pocket is created under the plate.

Cancellous bone is harvested from the iliac crest. The soft tissue pocket under the plate is packed with cancellous bone. Be sure to overfill the space available.

The soft tissue pocket is closed as much as possible, and the wound is irrigated, drained, and closed. If IMF was needed, it is released.

CORTICAL BONE

The area to be reconstructed is exposed, either intraorally or extraorally. In some cases (e.g., prior tumor resection with primary plate reconstruction), a MRP is already in place bridging the defect. A cortical (preferably corticocancellous) graft is harvested and contoured to the defect.



FIG. 6-9

If a THRP was used, additional hollow screws should be placed into the bone graft and fixed to the plate with the expansion screws. If another type of MRP was used, then placement of screws into the graft is not advised, although this is a controversial issue.

If the defect has not been bridged previously (e.g., osteomyelitis or secondary tumor reconstruction), then several options are available. First, of course, the proper positioning of the remaining segments is essential. Occlusion should be reestablished (using IMF), and the vertical rami and condyles should be positioned neutrally. Reconstruction can now be performed.

The options include the following.

1. A MRP, preferably a THRP, can be bent to shape and applied to stabilize the position of the fragments, using at least three or four screws on each side of the defect. The graft is carefully contoured to fit the defect (see Fig. 9). (If a THRP is used, additional hollow screws may be placed into the graft and fixed to the plate with the expansion screws.) If possible, the cortical graft may be wedged tightly between the mandibular fragments. This offers some stability without the placement of screws through the graft.
2. Another alternative is to shape the graft so that a portion overlaps the solid bone on each end. Generally, the overlapping portion of the graft is thinned or cut out so that the shape stabilizes the bone position, i.e., the graft bone overlapping the solid mandible bone is thinned so that the end of the solid mandible abuts against the thicker portion of the bone (like a lap joint). Lag screws are then placed through the graft into the mandible so that the gliding hole is in the graft. This rigidly stabilizes the graft to the mandibular bone.

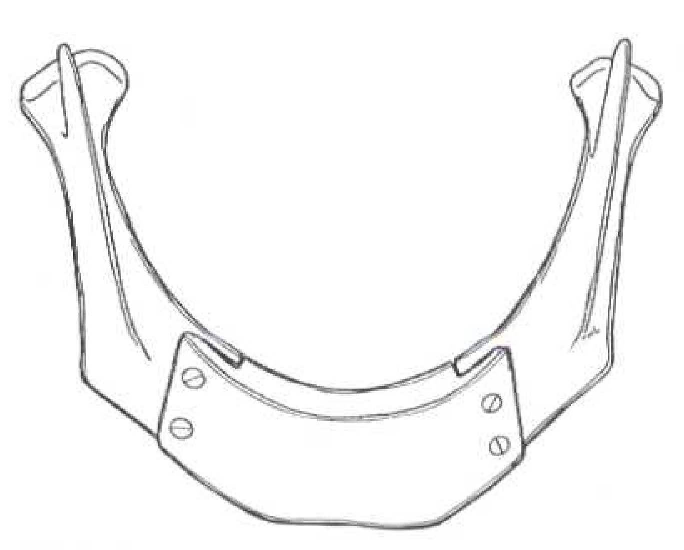


FIG. 6-10

The soft tissue is closed, and the wound is irrigated, drained, and closed. If IMF was needed, it is now released.

Pitfall: The use of miniplates or compression plates with a cortical bone graft (nonvascularized) is not recommended. The risks of screw loosening and infection are considered to be high.

COSTOCHONDRAL RAMUS/CONDYLAR RECONSTRUCTION

Key Principles	pp. 50–56
Surgical Approach	pp. 85–86

Occlusion should be established using IMF. The exposure of the ramus and temporomandibular joint is achieved, extending from the angle to the glenoid fossa by using an external approach. A preauricular approach may be used, or a Risdon (submandibular) approach may suffice. In either case, great care is needed to avoid injury to the facial nerve. After harvesting and preparing the costochondral graft, it is placed in position, with the mandible in a neutral position (the patient is in IMF).

The graft is secured from below with a bone clamp or modified towel clip.

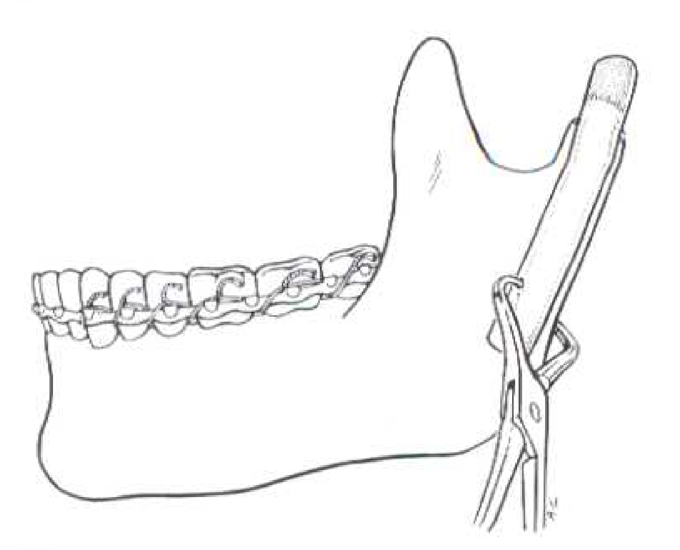


FIG. 6-11

Lag screws (sometimes through a plate, although this is optional) are used to secure the graft. A gliding hole (generally, 2.7 mm) is drilled in the vertical ramus through the graft. Next, a hole to be threaded (generally, 2.0 mm) is drilled in the vertical ramus through the gliding hole. The depth is measured. Be sure to catch the deepest cortex with the depth gauge. (If needed, the hole is tapped.) The appropriate-length screw is inserted and tightened. At least two screws are placed, although three or four screws are preferable.

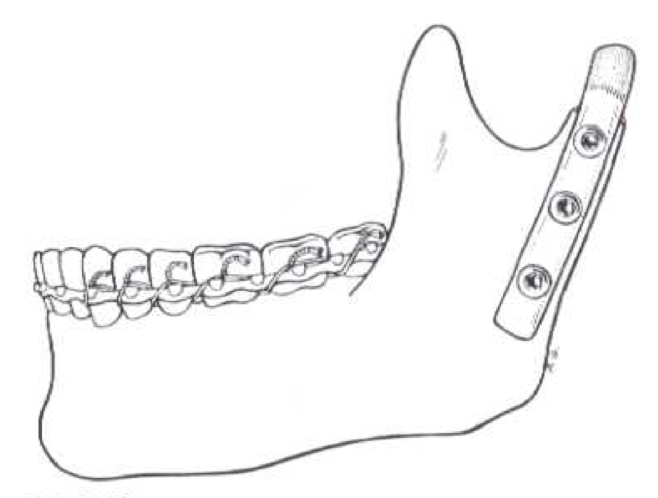


FIG. 6-12

If a plate is used, it merely functions as a washer so that the screw heads do not pull through the thin bony cortex. The screws are passed through the plate holes and the gliding holes in the graft into the threaded holes in the underlying ramus. (The 2.0-mm screws may be used through a miniplate. In this case, the gliding holes are drilled with a 2.0-mm drill, and the threaded holes are drilled with a 1.5-mm drill.)

The decision as to whether to leave the patient in IMF or not is up to the discretion of the surgeon.

UNIT VII

Mandible Orthognathic

UNIT OUTLINE

CHAPTER 1

Genioplasty

GENIOPLASTY PLATE

Key Principles	pp. 58–61
Surgical Approaches	p. 71

After performing the osteotomy, the mobilized segment is repositioned and held in position with a bone clamp. An appropriate chin plate is selected, based on the predetermined amount of advancement.

The holes are drilled in a monocortical fashion, taking care to place the holes more than 5 mm away from the roots of the adjacent teeth.

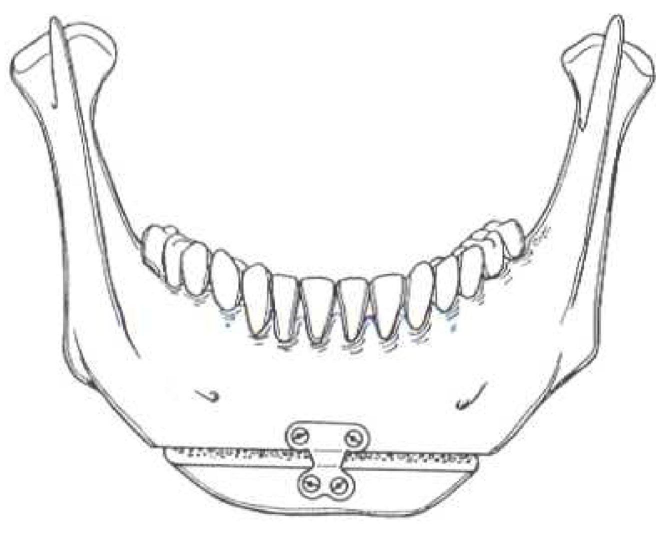


FIG. 7-1

POSITION SCREW

Key Principles	p. 56
Surgical Approaches	p. 71

After performing the osteotomy, the mobilized segment is repositioned and held in position with a bone clamp. The midline of the segment and the mandible are scored, and the screw position is marked on each side of the midline.

The surgeon chooses a 2.0- or 2.7-mm diameter screw, according to personal preference. While the segment is held in the correct position, a hole is drilled through the segment and the mandible corresponding to the core diameter of the screw. Care must be taken to avoid the mandibular canal and the tooth roots.

The depth of the hole is measured with the depth gauge, and a screw of appropriate length is inserted. The same procedure is repeated on the opposite side.

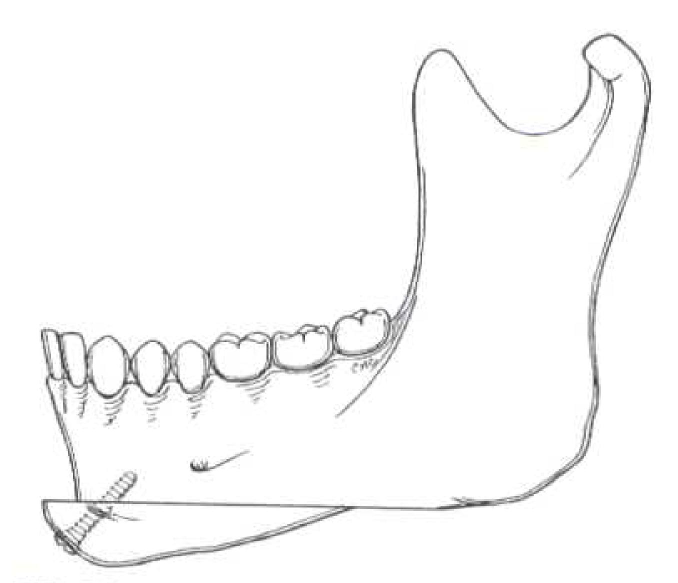


FIG. 7-2

CHAPTER 2

Midline/Paramedian Osteotomy

MINIPLATES

Key Principles	pp. 58–61
Surgical Approaches	p. 71

The osteotomies are performed, and the segments are repositioned and held in place with splints and/or MMF (Maxillo-Mandibular Fixation). A bone clamp can aid in stabilizing the inferior segment.

Two miniplates, each at least four holes in length, are contoured to the buccal cortex. The first plate is placed at the inferior edge of the vertical osteotomy. The second is placed 5 mm above the first but safely below the tooth roots. Monocortical holes are drilled, and screws are placed in the buccal cortex.

Two additional miniplates are placed across the horizontal osteotomy in a monocortical fashion.

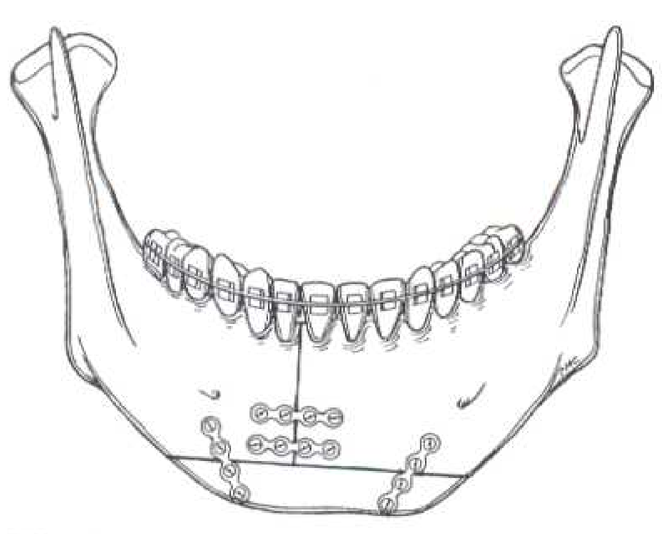


FIG. 7-3

***NOTE:** If a vertical osteotomy only is used, then two parallel miniplates are placed inferiorly. The stability should be evaluated and additional fixation applied if necessary.*

MINICOMPRESSION PLATE/ NEUTRAL MINIPLATE

Key Principles	pp. 58–61, 62
Surgical Approaches	p. 71

The osteotomies are performed, and the segments are repositioned and held in place with splints and/or MMF. A bone clamp can aid in stabilizing the inferior segment.

A minicompression plate is contoured to the buccal cortex at the vertical osteotomy site; 1 mm of overbending at the osteotomy is necessary to prevent lingual cortical splaying. A hole is drilled in the medial hole of the plate in an eccentric fashion. Following screw placement, an eccentric hole is drilled in the opposing medial hole of the plate. A screw is placed, and compression is achieved when the screw is tightened.

The two remaining lateral holes are drilled in the neutral position, and the screws are inserted. If the surgeon prefers to use a tension band plate, then a four-hole miniplate can be implanted 5 mm above the compression plate and well below the tooth roots.

Two additional miniplates are placed across the horizontal osteotomy in a monocortical fashion.

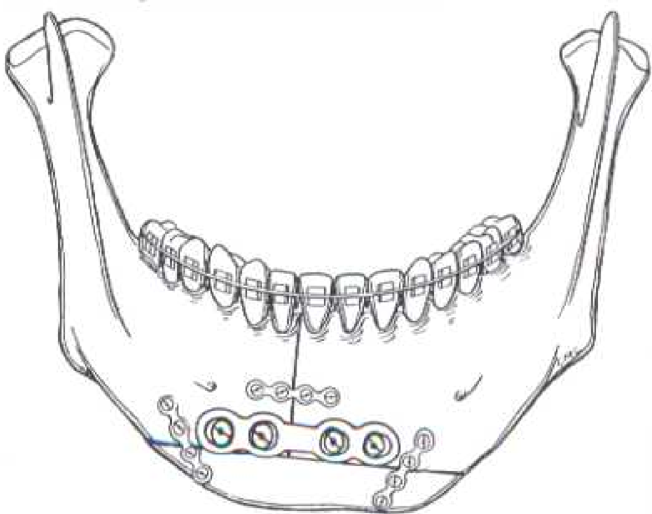


FIG. 7-4

***NOTE:** If a vertical osteotomy only is used, then the compression plate is placed along the inferior border, and the tension band miniplate is placed 5 mm above this plate.*

CHAPTER 3

Sagittal Split Osteotomy

CONDYLAR POSITIONING

An incision is made, exposing the ramus and angle. A second incision is made in the maxillary vestibule, exposing the lateral buttress. A long L-shaped plate is contoured to span the gap between the proximal segment and the lateral buttress. Monocortical holes are drilled in the proximal segment, and the screws are placed. The lateral buttress holes are drilled next, and the screws are placed. This process is then repeated on the contralateral side.

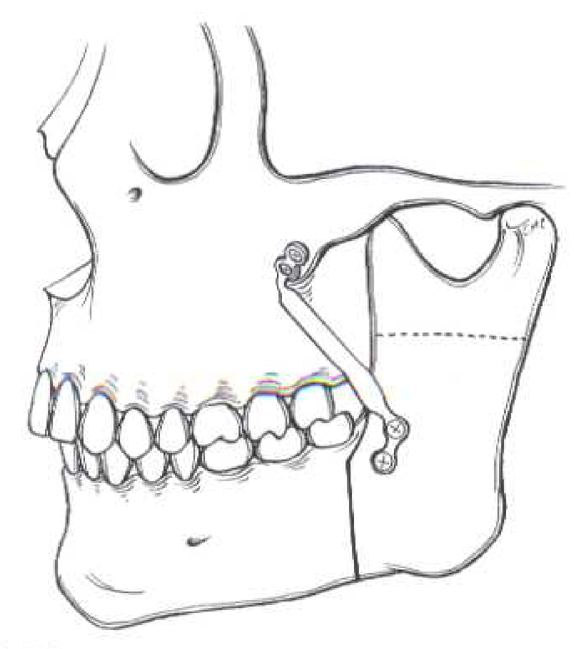


FIG. 7-5

The screws and plates are removed from each side, and the osteotomy is performed. After securing the distal segment into the new occlusion, the plates and screws are reapplied to each side prior to the osteosynthesis. The condyle is now oriented in its presurgical position.

MINIPLATE

Key Principles	pp. 58–61
Surgical Approaches	p. 77

The osteotomy has been performed, the distal segment is stabilized in its new position, and the proximal segment is properly positioned. The proximal and distal segments are brought into bone contact and secured.

A miniplate is contoured to the surface of the buccal cortex, crossing the osteotomy at the superior aspect. Monocortical holes are drilled, and the screws are inserted, making certain that at least two screws are placed on each side of the osteotomy.

A second miniplate is contoured on the buccal cortex. The holes are drilled monocortically, and the screws are inserted.

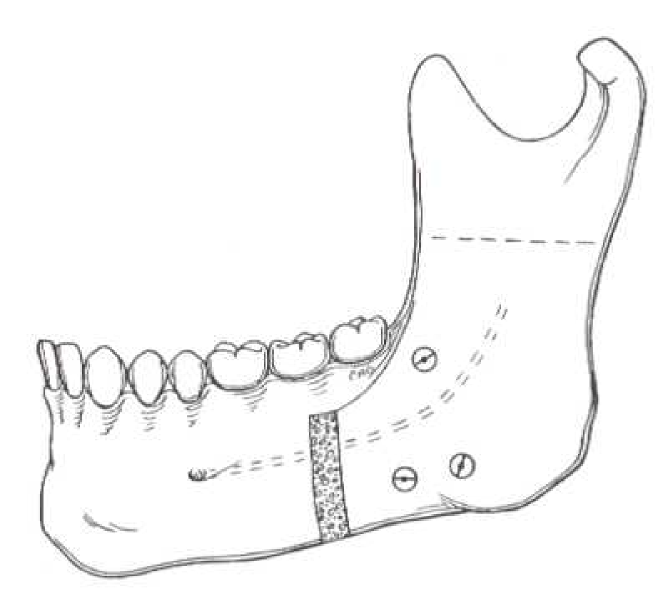


FIG. 7-6

NOTE: *Fixation of the sagittal split osteotomy is most commonly secured with screw fixation techniques. If plate fixation is used, the use of MMF and/or elastics is at the preference of the surgeon.*

SCREW FIXATION

Key Principles	pp. 50–56
Surgical Approaches	p. 77

Position Screw

The osteotomy has been performed, the distal segment is stabilized in its new position, and the proximal segment is properly positioned. The two segments are brought into proper position and secured.

A trocar is inserted through the skin of the cheek overlying the angle, and the tip is delivered into the wound. A drill guide of appropriate diameter is inserted, and a hole is drilled through both segments above the mandibular canal. The depth is measured (tapped if necessary), and the screw is inserted.

Two more holes are drilled in an identical fashion below the mandibular canal, and the screws are inserted.

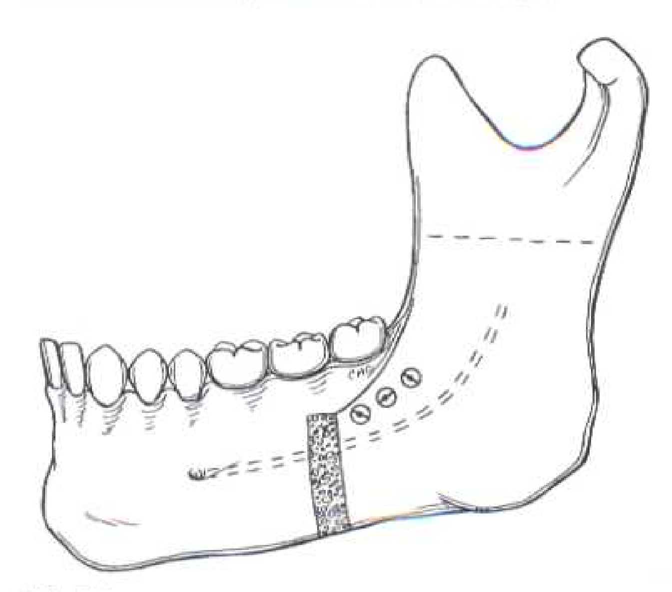


FIG. 7-7

A second method of screw placement is to place two screws above and one screw below the mandibular canal.

A third method of fixation uses three screws (2.0-mm diameter) placed along the superior border.



FIG. 7-8

The position screw technique allows stable fragment fixation without compression of the segments.

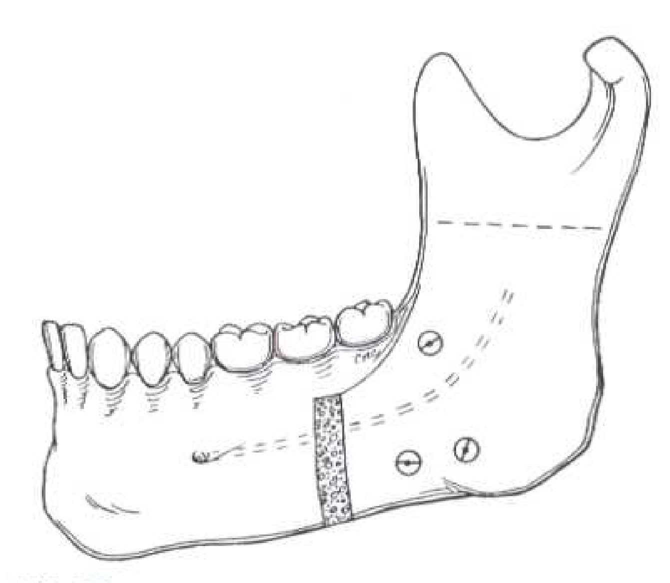


FIG. 7-9

Lag Screw

The osteotomy has been performed, the distal segment is stabilized in its new position, and the proximal segment is properly positioned. The proximal and distal segments are brought into bone contact and secured.

A trocar is inserted through the skin of the cheek overlying the angle, and the tip is delivered into the wound. A 2.7-mm drill guide is inserted into the trocar, and a 2.7-mm hole is drilled into the proximal segment above the mandibular canal. A 2.0-mm drill guide is next inserted into the hole in the proximal segment, and a 2.0-mm hole is drilled in the distal segment.

The depth is measured (tapped if necessary), and the screw is inserted. Compression is achieved as the screw is tightened.

Two more holes are drilled in identical fashion below the mandibular canal, and the screws are inserted.

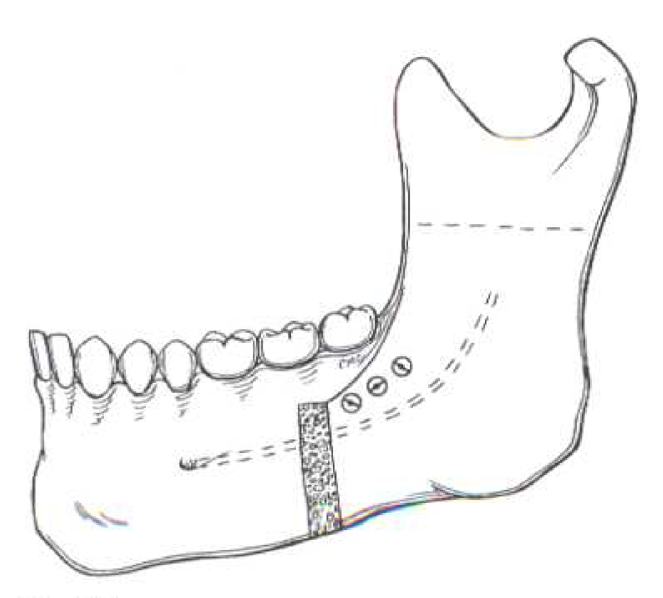


FIG. 7-10

A second method of screw placement is to place two screws above and one screw below the mandibular canal.

A third method of fixation uses three screws (2.0 mm) placed along the superior border.

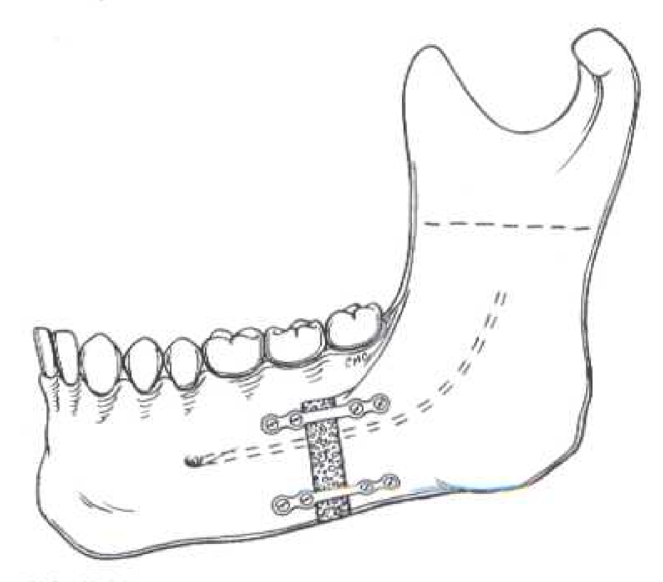


FIG. 7-11

The lag screw technique allows fixation of the segments with compression.

NOTE: *Lag screw fixation of the sagittal split osteotomy is controversial. The compression achieved can alter the relationship of the condylar head to the glenoid fossa. The surgeon should review the literature and decide which technique is appropriate for each case.*

CHAPTER 4

Total Subapical Osteotomy

Key Principles	pp. 58–61
Surgical Approaches	p. 71–76

After completion of the osteotomy, the dentoalveolar segment is stabilized in the desired occlusal relationship. A miniplate is contoured to the buccal cortex at the distal portion of the osteotomy. The monocortical holes are drilled, and the screws are placed.

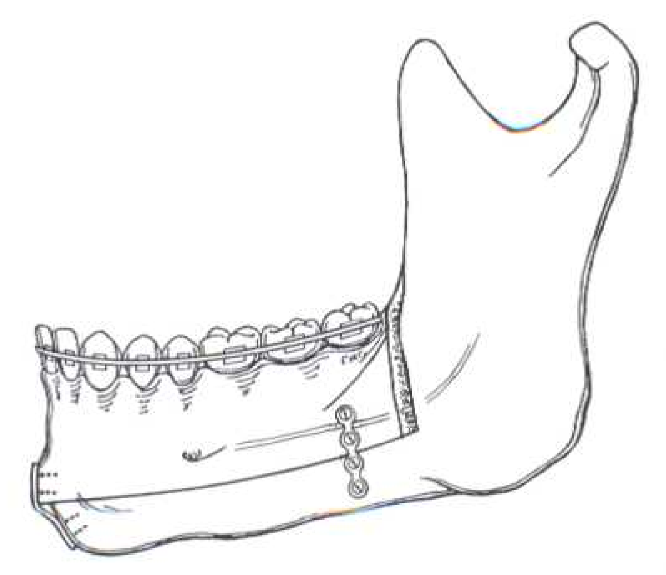


FIG. 7-12

After bilateral stabilization is achieved, a third miniplate is placed vertically in the midline. The plate is contoured to the buccal cortex, monocortical holes are drilled, and the screws are placed.

(Option) A single lag or position screw may be used instead of a miniplate to stabilize the dentoalveolar segment in the midline.

CHAPTER 5

Inverted L with Graft

Key Principles	pp. 58–61
Surgical Approaches	
Intraoral	p. 77
Extraoral	p. 83

After completion of the osteotomy, the mandible is secured in its new position. The graft is interposed between the proximal and distal segments.

A trocar is inserted through the cheek at the level of the horizontal osteotomy. The drill guide is inserted, the plate is contoured to the buccal cortex bridging the graft, and the holes are drilled. Screws are then inserted.

A second plate is placed inferiorly in an identical fashion as the first.

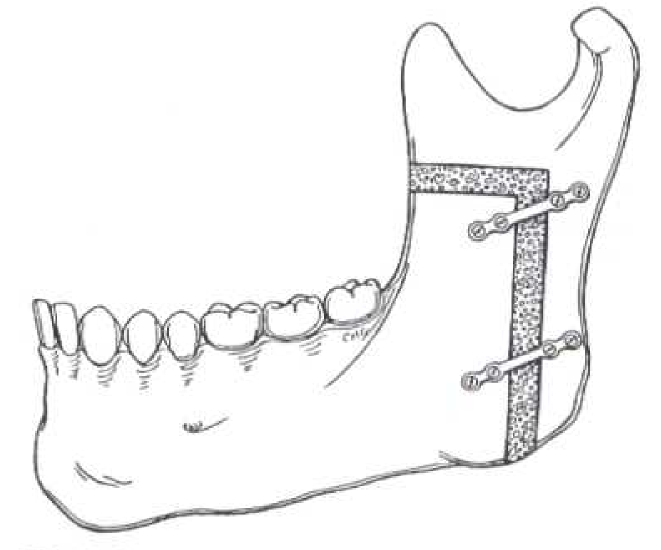


FIG. 7-13

CHAPTER 6

Vertical Ramus Osteotomy

Key Principles	pp. 58–61
Surgical Approaches	
Intraoral	p. 77
Extraoral	p. 83

The osteotomy has been performed, and the distal segment is stabilized into the correct occlusal relationship.

Two four-hole miniplates are placed across the osteotomy, being contoured exactly to the overlapping segments. The screws are secured in a monocortical fashion. If a straight plate is excessively long, such that one hole extends beyond the posterior border, then the L- or T-shaped plate should be used in order to place at least two screws on each side of the osteotomy.

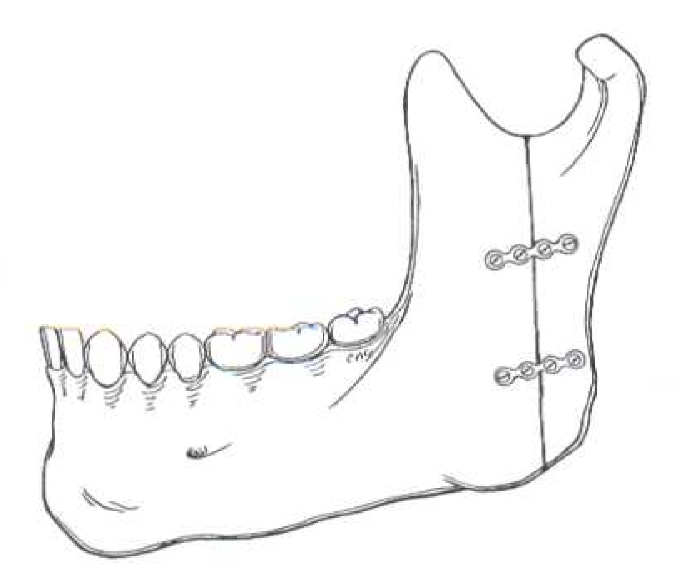


FIG. 7-14

(Option) Lag or position screws may be used in lieu of miniplates. At least two to three screws should be used, and care must be taken to maintain the proper condylar position.

CHAPTER 7

Costochondral Graft

Key Principles	p. 50
Surgical Approaches	p. 85–86

The osteotomy has been performed, and the distal segment is stabilized into the correct occlusal relationship.

The exposure of the ramus and temporomandibular joint is achieved extending from the angle to the glenoid fossa. This is accomplished utilizing a preauricular incision (face lift incision) in combination with a Risdon approach, taking care to preserve the facial nerve.

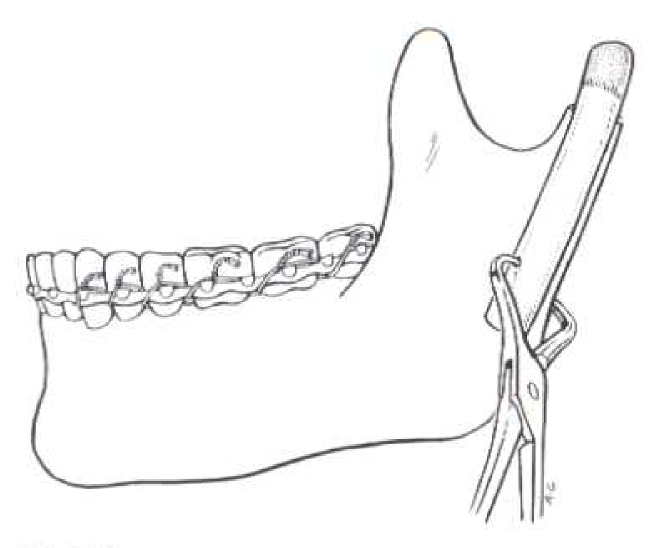


FIG. 7-15

Lag screws are used to secure the graft. A 2.7 mm gliding hole is drilled in the graft. Next, a 2.0 mm threaded hole is drilled in the ramus through the gliding hole. The depth is measured, the hole tapped and the screw inserted. At least two screws are inserted.

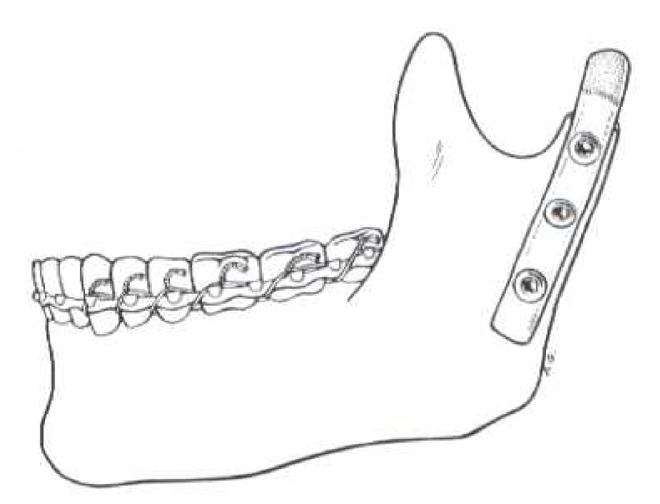


FIG. 7-16

The decision of whether to continue MMF is at the discretion of the surgeon.

UNIT VIII

Mid and Upper Facial Trauma

UNIT OUTLINE

CHAPTER 1

Frontal/Cranial

The bones of the cranial vault, including the anterior wall of the frontal sinus are not under stress and can be easily repaired with a minimum of fixation. Microplates and three-dimensional microplates are adequate and work nicely. They also are thin enough not to show through the thin frontal skin. (Management of the frontal sinus is controversial, and it is beyond the scope of this atlas.)

Exposure is generally accomplished using the coronal incision. For simple, unilateral fractures, a brow incision may be used. (Note that the brow incision results in numbness from the brow superiorly.)

SIMPLE

Key Principles	pp. 58–61
Surgical Approaches	p. 87

The bony fragments are realigned. A microplate is bent to the appropriate contour and applied with short (3- to 5-mm) microscrews.

COMMINUTED

Key Principles	pp. 58–61
Surgical Approaches	p. 87

A microplate is generally used to span comminuted areas from solid bone to solid bone. The comminuted fragments are repositioned and held up against the plate with a skin hook or Ragnel retractor for countertraction. A hole is drilled in the fragment, and a screw is placed, thereby stabilizing the fragment to the plate. This process is repeated for each bone fragment until the fractures are reduced. Additional screws are placed as desired. Sometimes, fragments may be wired together prior to plate fixation.

SEVERELY COMMINUTED

Key Principles	pp. 58–61
Surgical Approaches	p. 87

In some cases, the fragments are so comminuted that the reduction cannot be accomplished *in situ*. In this situation, the fragments are repositioned on the back table. If need be, they are wired together as the puzzle is solved.

Microplates can then be used to stabilize the fragments to each other. Overlapping segments of plate extend beyond the realigned fragments; therefore, these plate segments will support the anterior sinus wall in position.

Screws are placed through the overlapping plate segments into the solid frontal bone, thereby stabilizing the fracture.

After fixation is complete, the wound is irrigated, drained, and closed.

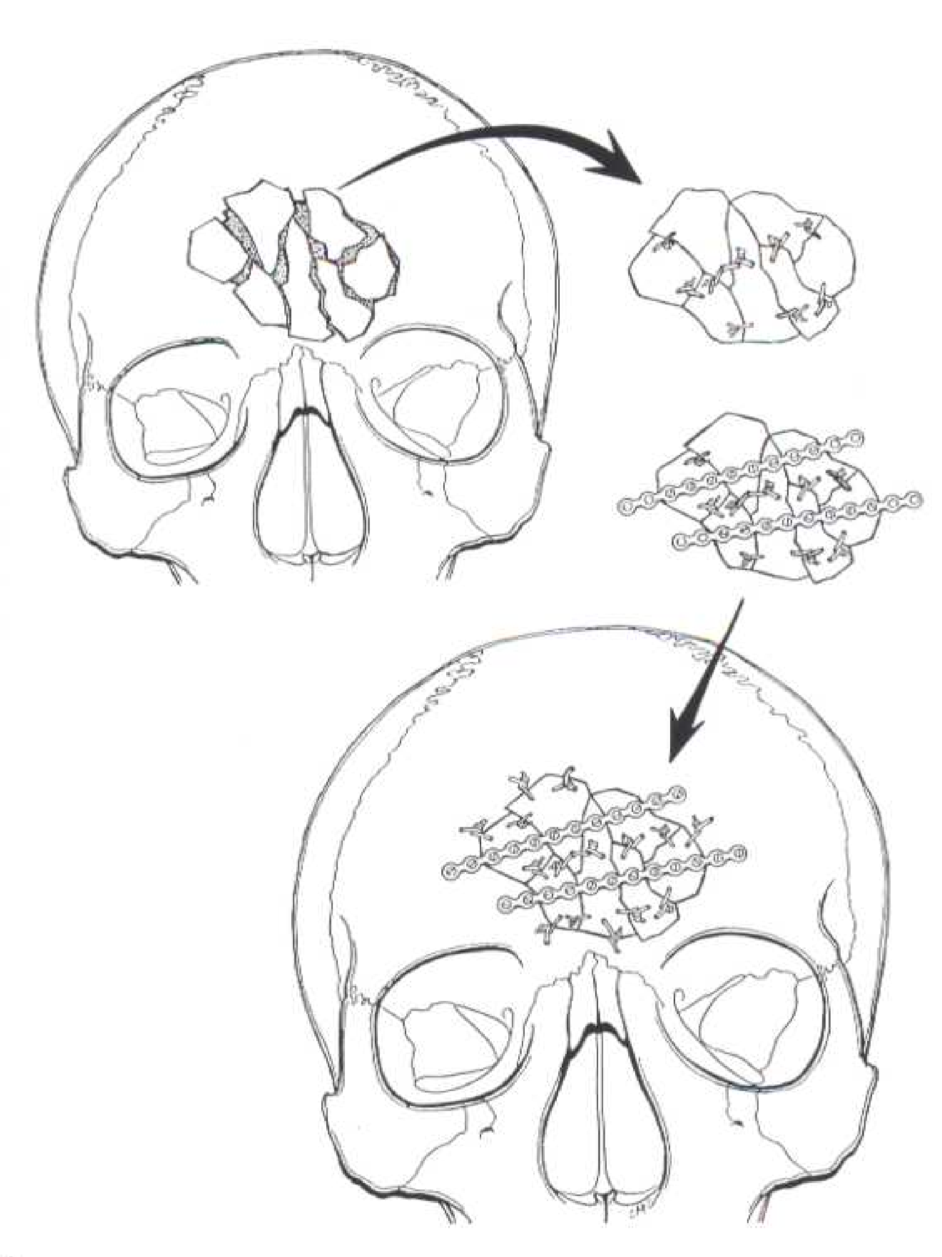


FIG. 8-1

CHAPTER 2

Zygomatic Arch

Repair of the zygomatic arch is simple after it has been surgically exposed. The exposure, however, is difficult. Therefore, the depressed arch is often treated from a distance, elevated transorally, or by a Gillies's approach (i.e., an incision in the temporal hair and elevation under the temporalis fascia). When simple elevation is not technically feasible (as a result of comminution or instability), the arch is best exposed through a coronal (or hemicoronal) incision.

After it is exposed, the fragments must be reduced. This may require the release of masseteric fibers if fragments are pulled inferiorly. Initial fixation with wire ligatures will help align the fragments in preparation for rigid fixation.

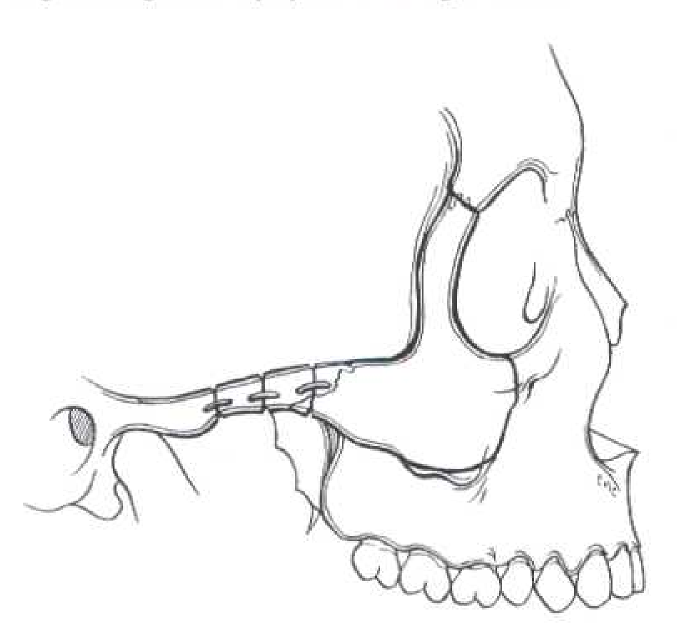


FIG. 8-2

A microplate (1.0-mm screws) is best suited for the repair of the zygomatic arch, although a small miniplate (1.5-mm screws) may be satisfactory. (Larger miniplates are not advised because they are likely to be visible and palpable through the skin.)

A single plate of sufficient length is bent to the shape of the reduced zygomatic arch and held in place with an instrument. This is usually fixed to the solid bone on each end with screws. The smaller intervening fragments are then stabilized to the plate and, thereby, fixed in position.

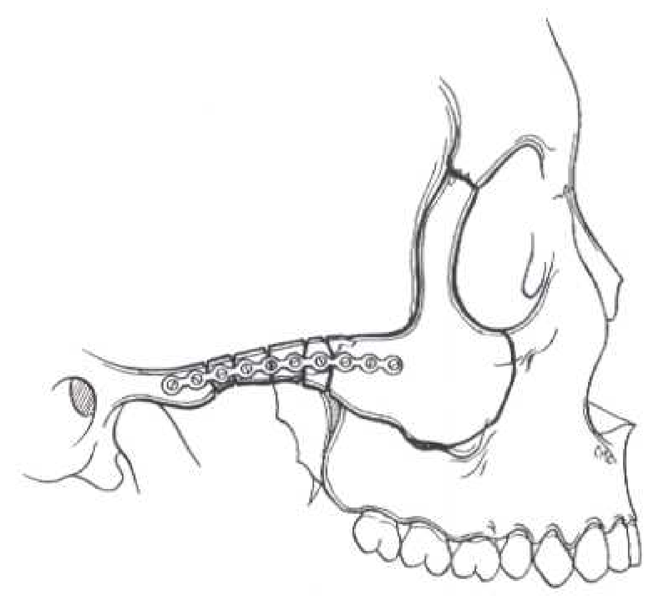


FIG. 8-3

Wire ligatures, if present, may be left in place or removed. The wound is irrigated, drained, and closed.

CHAPTER 3

Zygomatic "Tripod" Fractures

The zygomatic fracture involves the zygomatic arch (at various sites), the lateral orbital rim and wall, the infraorbital rim and orbital floor, and the anterior and lateral maxillary sinus at the zygomaticomaxillary buttress. It may occur in isolation or in association with Le Fort fractures.

Displacement may be minimal, moderate, or severe. Comminution and/or bone loss may occur.

Regardless of the situation, the key to repair is (1) establishing the proper alignment, i.e., the three-dimensional anatomic position, prior to fixation and then (2) the fixation itself is not difficult. However, it must be adequate to maintain the position of the bone during healing.

Caveats: Do not ignore the orbit. When the zygoma is significantly displaced, the lateral and inferior (and even the medial) orbital walls are frequently damaged. The orbit is explored initially, but the zygomatic complex is repositioned prior to repair of the orbital wall defects. Keep in mind the following.

1. The presence of significant enophthalmos and/or entrapment requires orbital exploration and repair.
2. Severe displacement of the zygoma generally indicates the need for orbital exploration because enophthalmos and/or globe ptosis may develop as a result of reduction of the zygoma.
3. Significant herniation of orbital contents out of the orbit, as seen by computed tomography, even in the absence of clinical enophthalmos, suggests the need for orbital exploration because late enophthalmos is likely.

If there is injury to cranial nerve V2 (the infraorbital nerve), explore it. Decompression of the nerve at the fracture site may improve the chance of recovery.

REPAIR

Key Principles	pp. 58–61, 62
Surgical Approaches	p. 87, 109, 115, 125, 126

(Orbital repair is discussed separately, see Unit 8, Chapter 4.)

Identify the degree and direction of displacement by clinical examination and CT scans.

Minimally Displaced

For minimally displaced fractures, a percutaneous elevation with a bone hook is possible, or a sound or other elevator may be advanced under the malar eminence from behind the lateral orbital rim (through a brow or upper lid incision) or from below (through a sublabial incision).

The minimum fixation that will resist functional forces is a reasonably strong fixation along the lateral orbital rim. A minicompression plate using 2.0-mm screws may be used.

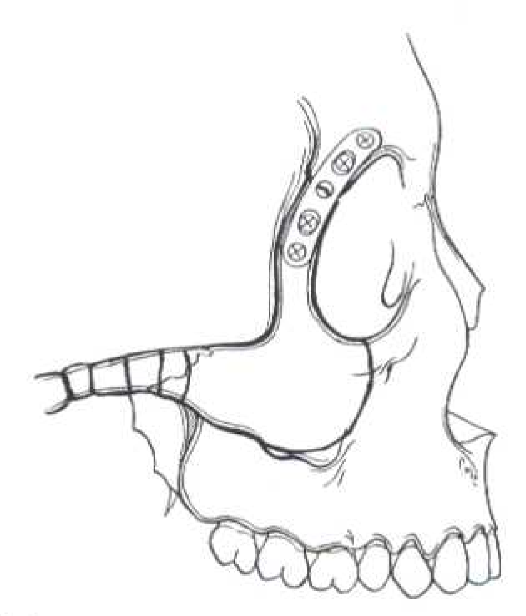


FIG. 8-4

A simple four- to six-hole miniplate may also be used.

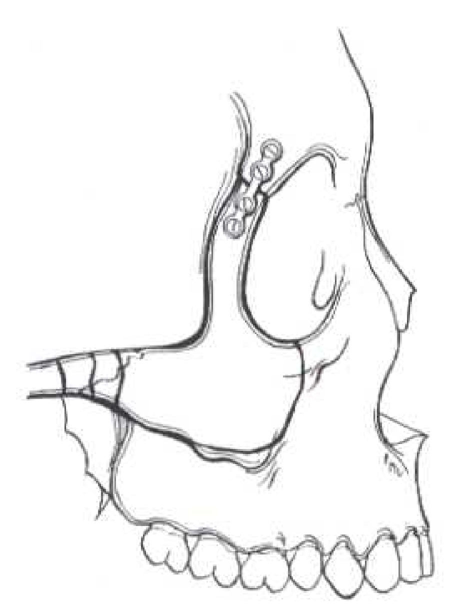


FIG. 8-5

A 2 × 3 six-hole microplate may provide adequate stabilization as a result of the structural advantage provided by the geometric shape.

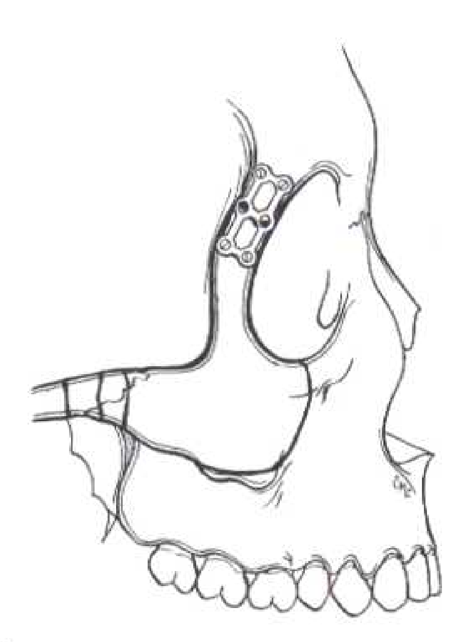


FIG. 8-6

A straight or curved microplate is inadequate unless multiple anatomical areas are fixed.

Fixation of the zygomaticomaxillary buttress alone is inadequate. Note, however, that exposure of the lateral orbital wall and the zygomaticomaxillary buttress may provide helpful information regarding the exact positioning of the malar complex. Plate or wire fixation of these areas, in addition to the lateral orbital rim, adds to the stability of the fixation.

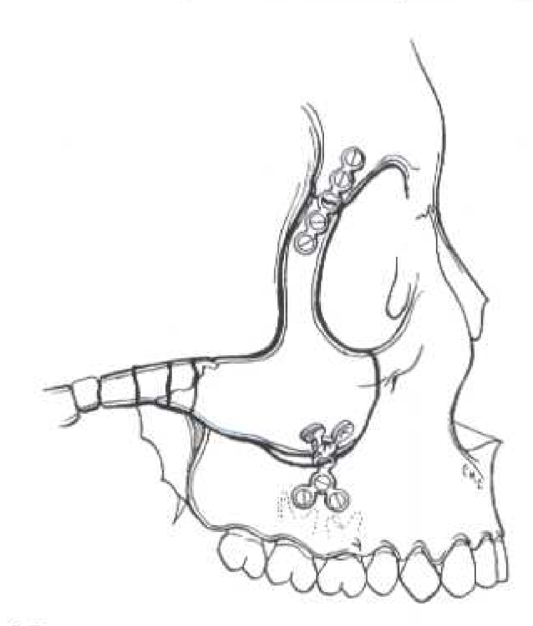


FIG. 8-7

Moderate or Severe Displacement

After determining the direction and degree of displacement, the exposure needed for repair must be decided. If there is significant loss of the anteroposterior dimension as a result of lateral rotation with fragmentation or telescoping of the zygomatic arch, a coronal approach may be necessary to reposition the zygomatic arch and use it to determine the exact anteroposterior position of the zygomatic bone. At least, the lateral orbital rim and zygomaticomaxillary area should be exposed. This will also allow visualization of the infraorbital rim during repositioning of the malar complex.

After satisfactory repositioning of the zygomatic complex has been achieved, fixation should include at least the lateral orbital rim and the zygomaticomaxillary buttress for true rigid stabilization (see Fig. 7).

When orbital floor exploration is necessary, direct exposure of the infraorbital rim (through a conjunctival or lower lid incision) allows fixation of this area with a microplate. This may be helpful in determining the three-dimensional position of the malar complex in same cases.

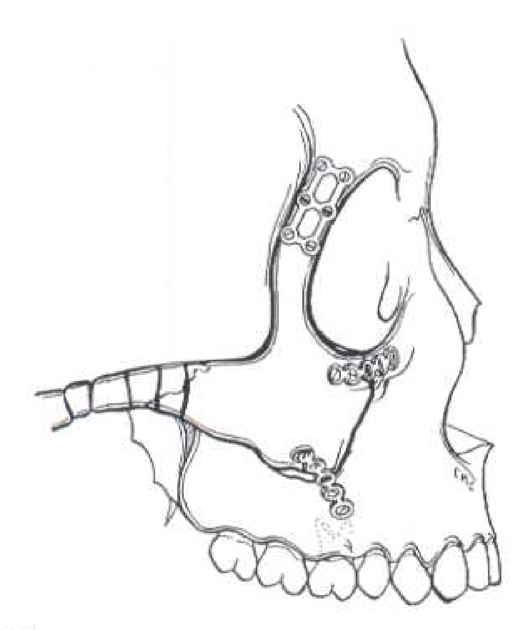


FIG. 8-8

Wire fixation of the fragments at various sites will help reposition the bones in their proper three-dimensional position in anticipation of rigid fixation with plates.

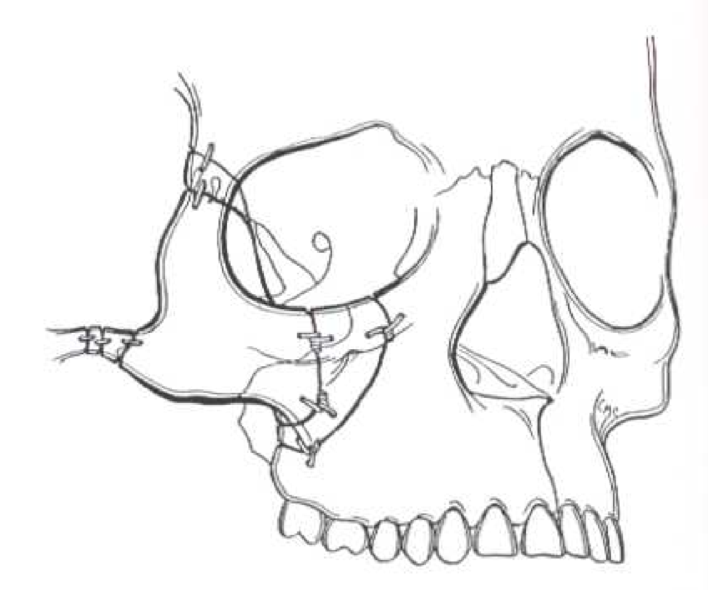


FIG. 8-9

Comminution, Bone Loss, and Associated Le Fort Fractures

These situations make exact repositioning and repair of the zygomatic complex difficult. Commonly, the zygomatic arch, infraorbital rim, and zygomaticomaxillary area are comminuted, and the lateral orbital rim alone (even if it is not comminuted also) does not provide adequate information as to the exact anatomical reduction. Preoperative CT analysis and wide exposure help in the reduction. The opposite zygoma, when intact, provides an invaluable reference point.

The frontozygomatic region, the lateral orbit, the malar eminence, and the zygomatic arch are exposed through the coronal incision. The infraorbital rim and orbital floor (and medial wall if needed) are exposed through a conjunctival or lower lid incision. The zygomaticomaxillary area is exposed through the sublabial incision.

When an associated Le Fort fracture is present, intermaxillary fixation (IMF) has been used to reestablish the occlusal relationship so that repair of the zygomaticomaxillary area does not create a malocclusion. In the following series of figures, associated Le Fort fractures are assumed. Repairs of the nasofrontal and maxillary fractures are indicated, leaving the zygomatic fractures to be repaired as described herein.

As a general rule, when comminution is severe, initial fixation of the multiple fractures with wire ligatures will help reduce the fractures and stabilize the position of the zygomatic complex in space.

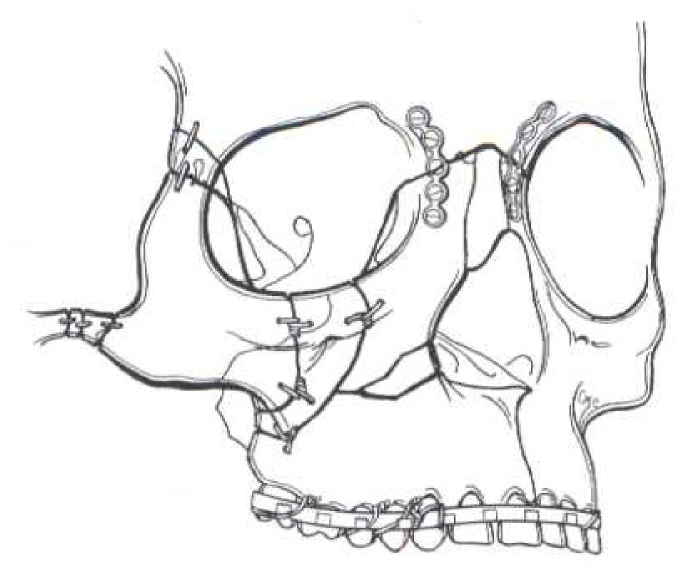


FIG. 8-10

Rigid fixation is generally begun from the stable to the unstable, using whatever reference points are available. A microplate or a small miniplate (1.5-mm screws) may be fixed along the zygomatic arch from the temporal root to the malar eminence. This will reestablish the anteroposterior dimension and help position the zygomatic bone in space (in reference to the remaining facial bones).

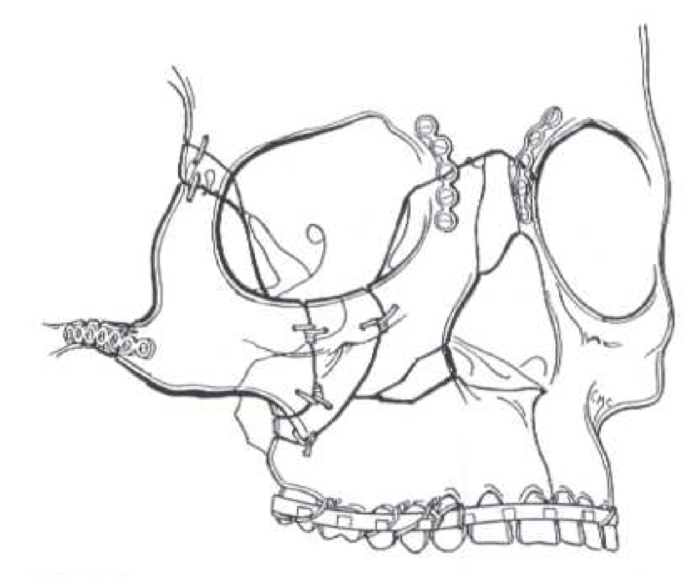


FIG. 8-11

Recreation of the lateral and infraorbital rims, using a miniplate or three-dimensional microplate along the lateral rim and a microplate along the infraorbital rim, will complete the three-dimensional repositioning of the bone.

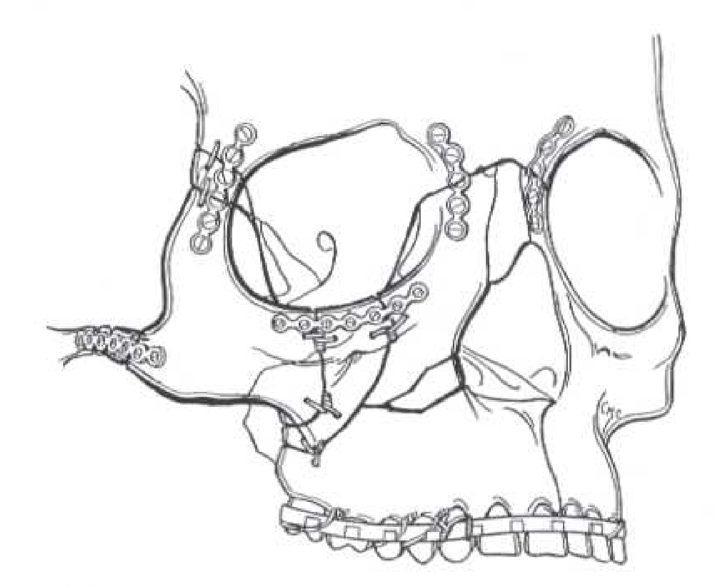


FIG. 8-12

If there is enough bone present at the zygomaticomaxillary buttress, then this area is aligned and plated. Whatever plate will connect the areas without injuring the tooth roots is the plate of choice.

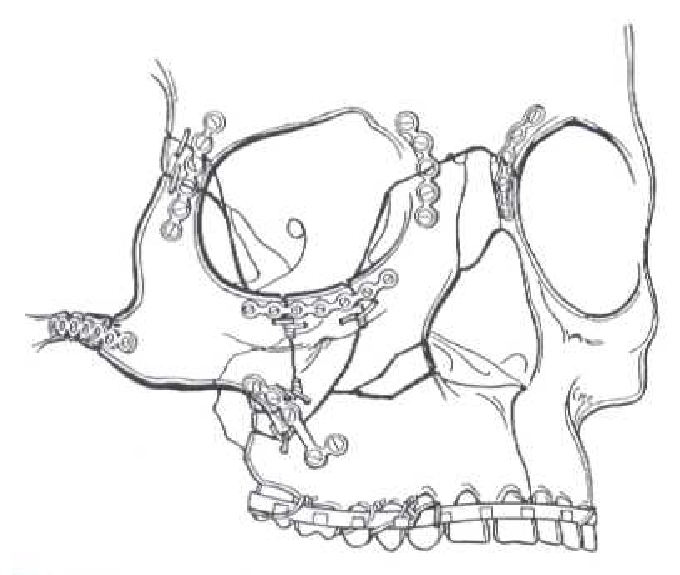


FIG. 8-13

(With the nasofrontal and zygomatic components of a Le Fort III fracture stabilized, only a Le Fort I component can remain. This is stabilized with plates as needed.)

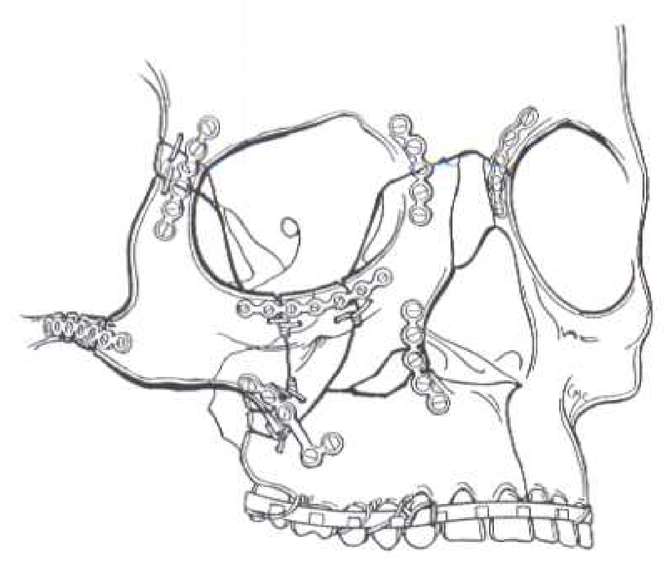


FIG. 8-14

If a significant defect is present at the zygomaticomaxillary buttress, the defect should be bridged with a bone graft. Lag screw fixation of the graft to the underlying bone at each end allows the graft to serve as a rigid fixation device while it bridges the gap.

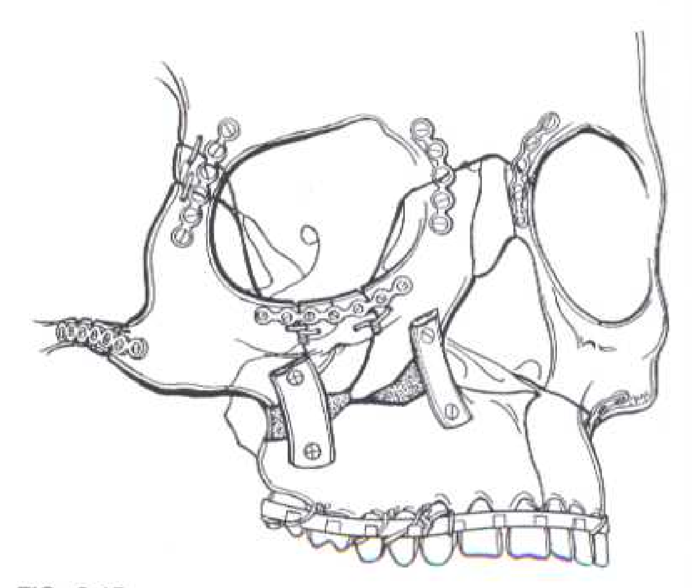


FIG. 8-15

CHAPTER 4

Orbital Defects

Significant orbital defects should be grafted to prevent the enlargement of orbital volume, herniation of orbital contents, and resultant globe ptosis and enophthalmos. Although various allograft materials can be used for this, the authors prefer and recommend the use of autogenous bone.

REPAIR

Key Principles	pp. 58–61
Surgical Approaches	p. 115, 120, 123

The orbit is explored using an appropriate incision for direct exposure of the defect area. The defect is identified, and any herniated tissues are reduced back into the orbit. They may be temporarily supported with a piece of alloplastic material. The defect is assessed, and an appropriate bone graft is harvested.

Split rib can be bent and contoured to the appropriate shape. If proper reshaping of the orbital contour with the rib results in the creation of a large dead space, the graft can be layered and wired together. When more than one width of rib is needed, the pieces can be fixed together with microplates or three-dimensional microplates.

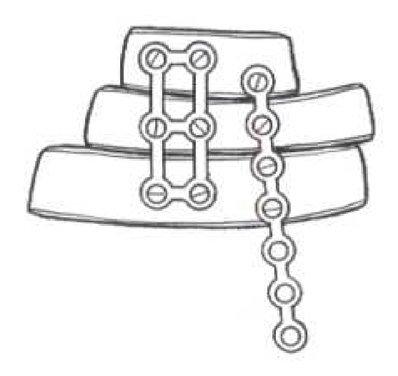


FIG. 8-16

After the desired shape has been achieved, a microplate is fixed to the graft along its anteroposterior dimension, with excess plate extending anteriorly for two to four holes. This will bend over the orbital rim, where screws will fix it, thus rigidly stabilizing the bone graft to the orbit.

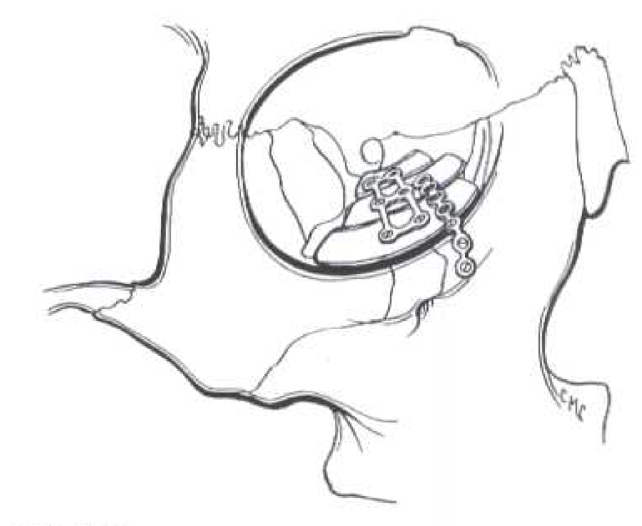


FIG. 8-17

Calvarial or iliac bone can also be used, and this can be similarly fixed with a microplate to the orbital rim. Because calvarial bone is hard and cannot be bent, if a curve is needed, the graft is cut and then fixed back together with a microplate.

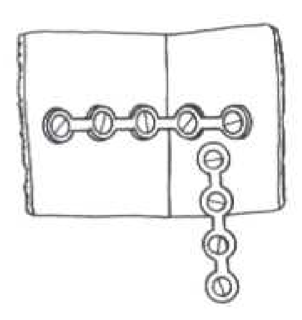


FIG. 8-18

The microplate is then bent to the desired curvature for orbital repair. A second microplate is used to fix the graft to the orbital rim.

The use of a specially designed orbital plate or mesh for reconstruction of orbital defects has been advocated, but this is not recommended by the authors.

CHAPTER 5

Nasal Fractures, Nasoethmoid (NE) Complex Fractures, and Nasal Defects

Of course, the simple nasal fracture is not opened for rigid fixation. However, when nasal fractures occur as a component of complex facial trauma, stabilization of the midface may include fixation of the nasal bones.

NOTE: *The presence of plates on the nasal bones interferes with secondary rhinoplasty if needed.*

The nasal root may be exposed by a direct horizontal incision, and the nasoethmoid complex requires bilateral lateral nasal dorsal (external ethmoidectomy) incisions. However, this area will generally be approached using the coronal incision.

NASAL FRACTURES

Key Principles	pp. 58–61
Surgical Approaches	p. 87, 109

1. When repairing the nasofrontal area, if the nasal bone is fragmented, the fragments are included to whatever degree is possible in the nasofrontal fixation with miniplates or microplates. Other nasal bone fragments may be repaired by using microplates.
2. When repairing the infraorbital rim, nasal bone fragments may be repaired with microplates, generally as a direct extension of the maxillary repair.
3. Sometimes, fractures of the lower nasal bones and/or nasal processes of the maxillae can be included with the repair of the medial vertical maxillary buttresses. These are generally stabilized with miniplates (or three-dimensional microplates).

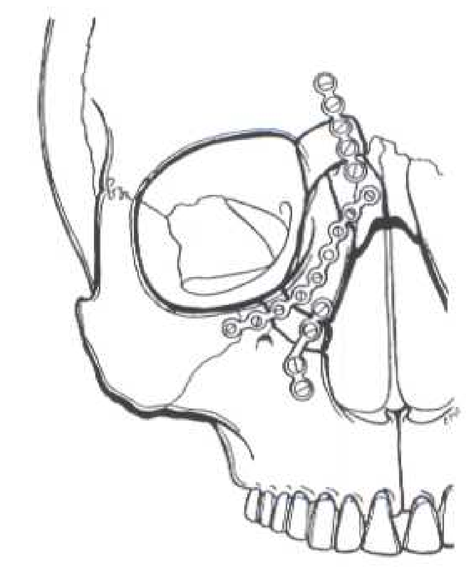


FIG. 8-19

NASOETHMOID COMPLEX FRACTURES (NASAL ORBITAL ETHMOID (NOE))

Key Principles	pp. 58–61
Surgical Approaches	p. 87

A simple nasoethmoid complex fracture may sometimes be repaired by using a plate that extends horizontally across the nasal dorsum. This is bent posteriorly to stabilize large lacrimal bone fragments (with the canthal tendons still attached) and hold them medially to prevent lateralization of the medial canthi.

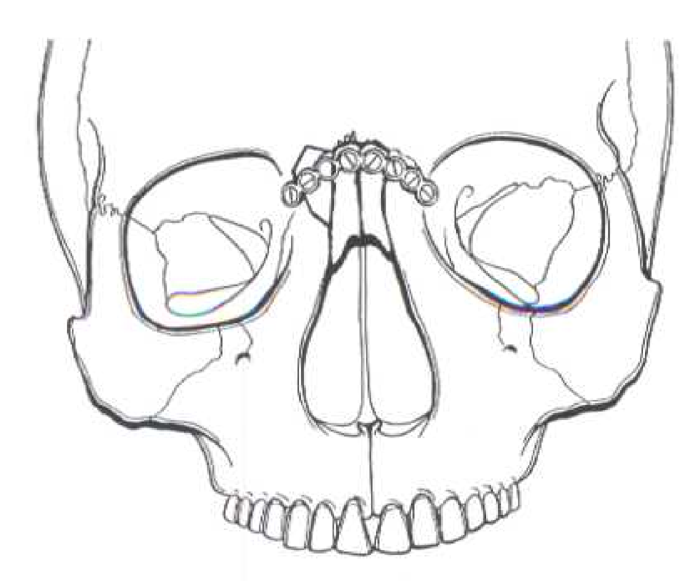


FIG. 8-20

More severe and typical nasoethmoid complex fractures require transcanthal wiring to prevent lateralization of the canthi. However, if the lacrimal and ethmoid bones are severely comminuted, the transcanthal wires may tend to ride forward, resulting in anterior displacement of the medial canthi. A miniplate can be placed to hold the wire posteriorly. After placement of the transcanthal wire, a miniplate is bent over the nasal dorsum so that it reaches the proper wire position on each side. The wires may be passed through and around the plate holes, or the holes that overlap the wire on each side may be cut in half across the width of the plate.

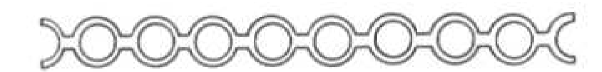


FIG. 8-21

This plate is then fixed over the nasal dorsum so that the transcanthal wires are held posteriorly by the plate. This will prevent anterior displacement of the wire.

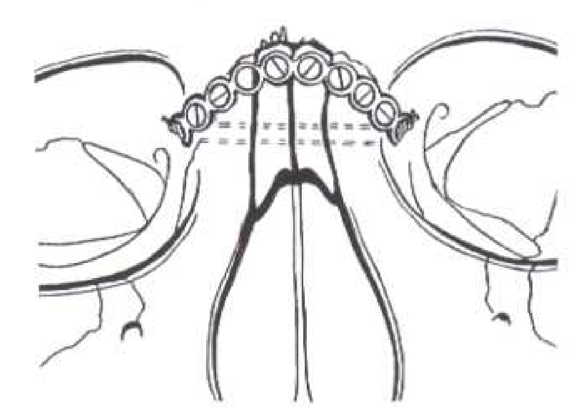


FIG. 8-22

As an alternative, bone grafts may be placed behind the nasal root remnant to recreate the medial orbital walls. The transcanthal wires are then passed through holes drilled in the bone grafts. This will hold the wire in position and prevent anterior displacement.

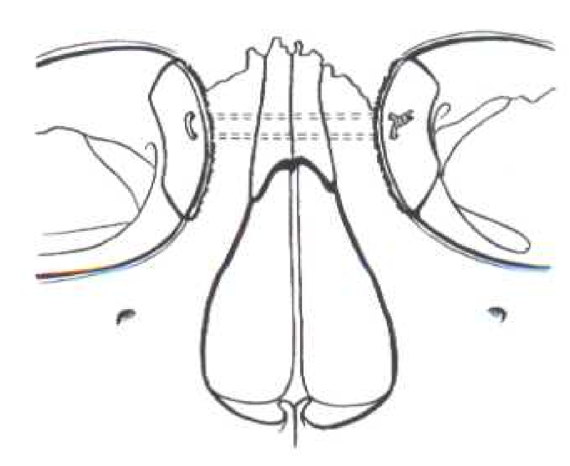


FIG. 8-23

Transcanthal wires may be placed across the nasal septum and through both medial canthal ligaments. Two alternative techniques may enhance the repair of the medial canthal positions.

1. When using wire for the repair, a 4–0 permanent suture may be placed as several loops through the canthal ligament. This suture is then caught with the wire to avoid tearing of the ligament by the wire.
2. Each canthal ligament may be sutured independently to the contralateral frontal bone after passage of the suture through the nasal septum. This requires drilling out the inferior frontal sinus or passage of a screw into the frontal bone around which the suture is tied while pulling the contralateral canthal tendon to the desired position.

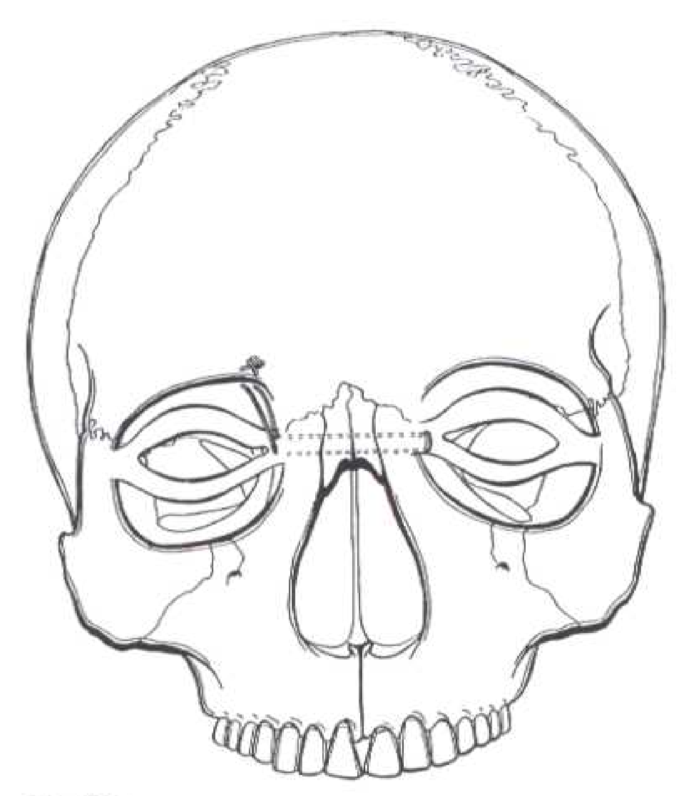


FIG. 8-24

NASAL DORSAL DEFECTS

Key Principles	pp. 50, 58–61
Surgical Approaches	p. 87

If the nasal dorsum is severely comminuted or lost, a cantilever bone graft can be fixed to the frontal cranium by using rigid fixation. Several techniques can be used for fixation of the bone graft. The graft is shaped to provide reconstruction of the nasal dorsal contour.

1. The graft can be designed to overlap the frontal bone. One or two lag screws can then be used (two are preferable) to fix the graft to the underlying frontal bone. The larger gliding hole is drilled in the graft. (This hole is the size of the screw thread.) A countersink is used to enlarge the hole so that the screw head sits flush in the graft. (This works well in the hard calvarial bone graft, although it may lead to splintering in a rib graft.) The second hole is drilled with the smaller drill (the size of the screw shaft) in the underlying frontal bone. A screw is placed and tightened, stabilizing the graft to the underlying frontal bone. A second lag screw increases the stability of the fixation and prevents possible rotation of the graft.

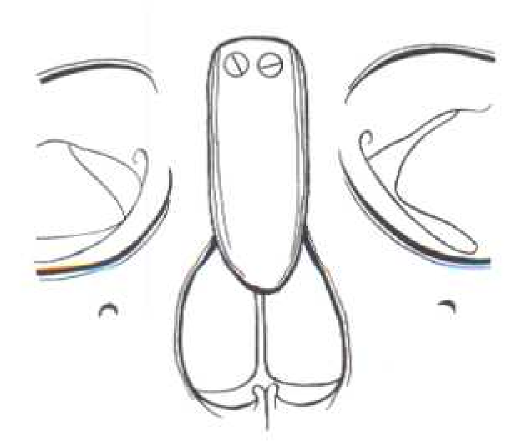


FIG. 8-25

2. The graft may be fixed to the frontal bone with a miniplate. In this case, the graft sits flush against the inferior edge of the frontal bone instead of overlapping it. At least two screws in the frontal bone and two screws in the graft will provide stabilization.

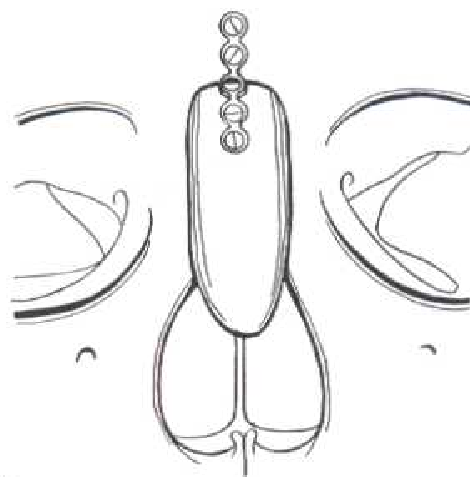


FIG. 8-26

3. The miniplate can be bent so that at least two holes overlap the frontal bone, and the plate comes down at right angles along the inferior frontal bone to the depth of the graft. The remainder of the plate sits under the graft and supports it. The plate is screwed to the undersurface of the graft so that the screws do not protrude. The graft and plate are positioned, and screws are placed through the plate into the underlying frontal bone.

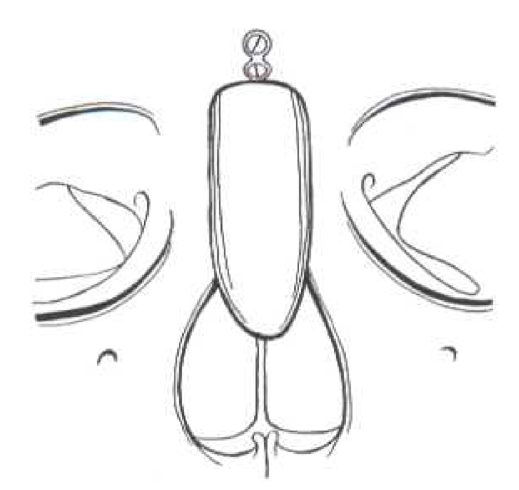


FIG. 8-27

Note that, although this technique prevents the plate from overlying the graft and showing through the nasal skin, it also places the plate between the graft and the inferior frontal bone, decreasing the chance of formation of a solid bony union. It is therefore not the recommended technique of the authors.

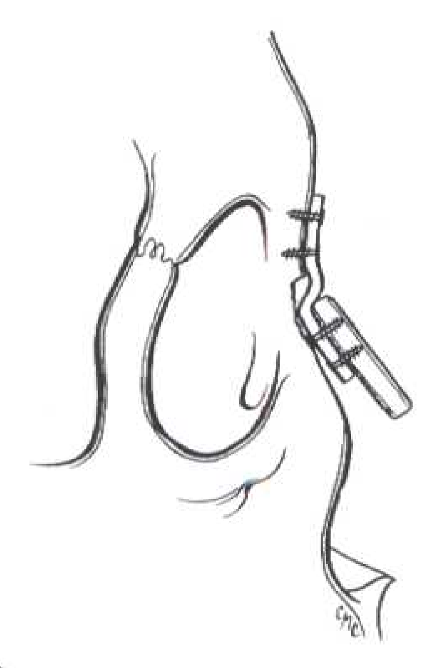


FIG. 8-28

CHAPTER 6

Le Fort I

The Le Fort I fracture may occur in isolation or in association with more complex Le Fort II and III fractures. The classic Le Fort I separates the lower maxillae from the rest of the face, traversing the maxillae horizontally through the pyriform apertures, the lower nasal septum, and the lateral and posterior walls of the maxillary sinuses.

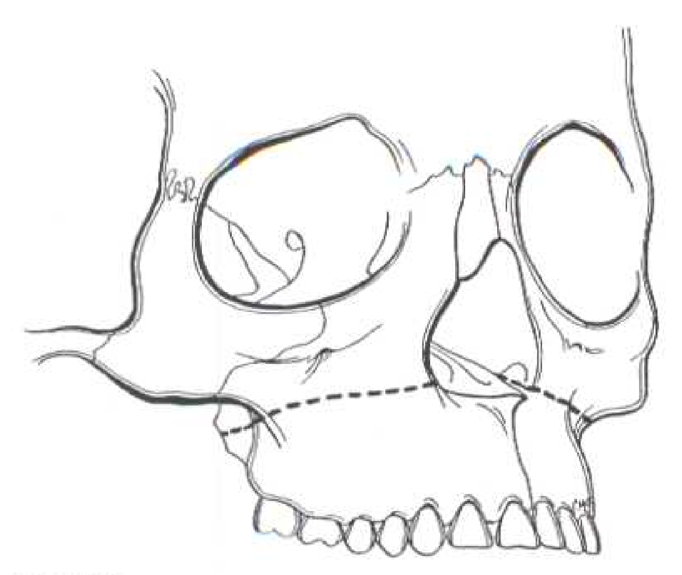


FIG. 8-29

In this atlas, we approach the more complex facial fractures by starting with the most complex components and simplifying them by converting them by sequential stabilization into simpler fractures. Thus, a complex Le Fort III fracture that includes Le Fort I and II components is classified as a complex Le Fort III. After the zygomatic component has been stabilized, Le Fort I and II fractures persist. Fixation of the nasofrontal area and infraorbital rims (and the nasoethmoid and orbital components when present) leaves only Le Fort I components, which are repaired as outlined in this section.

The presence of a split palate, severe comminution, and/or bone loss add additional complexity and are discussed individually.

REPAIR

Key Principles	pp. 58–61
Surgical Approaches	p. 109

Dentulous

Arch bars are first applied to the teeth and proper occlusion is reestablished if possible. If the teeth do not come together easily, disimpaction may be carried out immediately or deferred until the fractures have been exposed.

Edentulous

An arch bar or denture (splint) containing an arch bar is fixed to the mandible with circummandibular wires. A denture (splint) containing an arch bar is positioned over the maxillary alveolus to identify the occlusal relationships. Suspension wires are not used to secure the denture. However, the denture may be screwed into the palate if desired. (A 2.0- or 2.7-mm lag screw may be used for this purpose.)

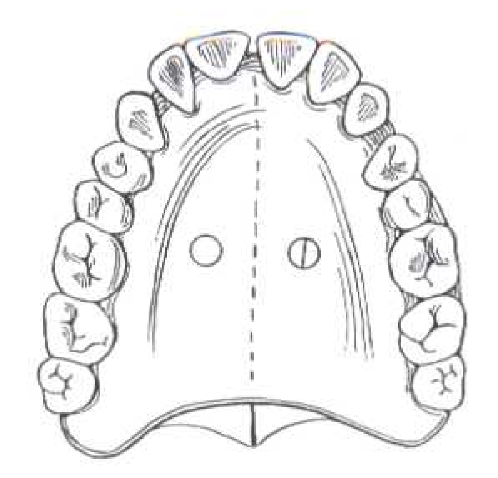


FIG. 8-30

The occlusal relationship is reestablished. If there is a gross discrepancy, the splint is removed, the midface is disimpacted, and the splint is replaced. (Attempting to disimpact the midface with the splint in place may fracture the splint.) Again, disimpaction may be deferred until after all fracture lines have been exposed.

A sublabial incision is made. The maxillary bone is exposed, using care to avoid elevation of the fractured fragments with the flap.

The fractures are identified and assessed, paying particular attention to the status of the four vertical buttresses, two on each side as follows: (1) the bone surrounding the pyriform aperture medially and (2) the maxillary wall laterally. At this time, if proper realignment has not been accomplished, disimpaction is carried out.

The bone fragments are aligned prior to fixation. Sometimes, they stay in position after reduction, but frequently, they must be reduced and held with an instrument, such as a small hook or a Ragnel retractor.

With an assistant holding the bones in position, the surgeon selects an appropriate plate for the most accessible fracture, generally at the pyriform aperture. No single plate shape is ideal. The plate selected should allow for the placement of at least two screws on each side of the fracture, without risking injury to tooth roots, particularly the high riding canine root.

NOTE: *Compression is not generally possible because of the thinness of the bones and the small amount of bone-to-bone contact. Also, by compressing the fractures, displacement of the maxillae can occur, resulting in a malocclusion. Neutral miniplates are therefore used.*

After the desired plate shape has been selected, a template may be placed directly on the bone and pressed into shape.

NOTE: *Some surgeons prefer to bend the plate to shape without the intervening step of using a template. (This is an individual decision, but experience is required because repeated bending weakens the plate.)*

The occlusion is rechecked before plate fixation is started. The plate is held in position with a finger or instrument, and the first hole is drilled. Countertraction on the bone with a hook or retractor lifting the bone against the drill bit may decrease the likelihood of fracture or displacement of the bone during drilling. Irrigation is used. A drill guide will decrease drill wobble. A depth gauge is used to measure the depth, and a self-tapping screw of appropriate length is placed and tightened.

NOTE: *Tapping the holes in the thin maxillary bones increases the risk of damaging the thread in the bone and is not recommended.*

Each hole is drilled and measured, and a screw is placed in turn until all the screws have been placed. Some surgeons do not measure the depth of the holes, generally using 4- to 7-mm screws as needed.

This process is then repeated at the second vertical buttress, generally the opposite pyriform aperture. Similarly, rigid fixation with miniplates is then performed sequentially at the remaining two buttresses.

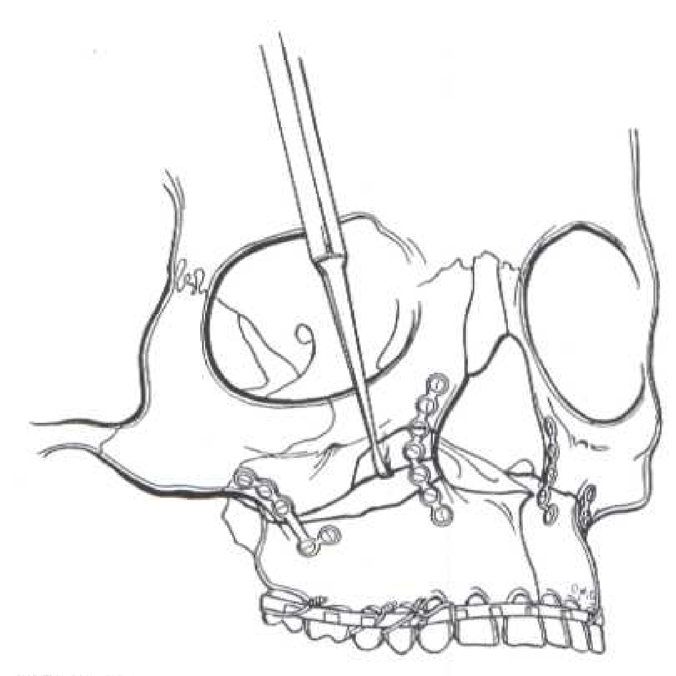


FIG. 8-31

At this point, the Le Fort I fracture should be rigidly fixed. Occlusion is rechecked, and IMF, if in place, is released. The incision is irrigated, drained, and closed in layers.

DEFECTS

Key Principles	p. 50
Surgical Approaches	p. 109

When bridging gaps greater than 5 to 10 mm, bone grafting is advised for increased stability during healing and to ensure a greater likelihood of bony union and a long-term stable result. Rib or calvarium is generally selected. The appropriate graft is harvested and shaped so that the bone graft overlaps the bone on either side of the defect. Lag screws may then be placed through each end of the graft and into the bone underneath. This serves to stabilize both the graft and the fracture. The graft itself serves as the rigid fixation device, thereby both bridging and stabilizing the fracture at once.

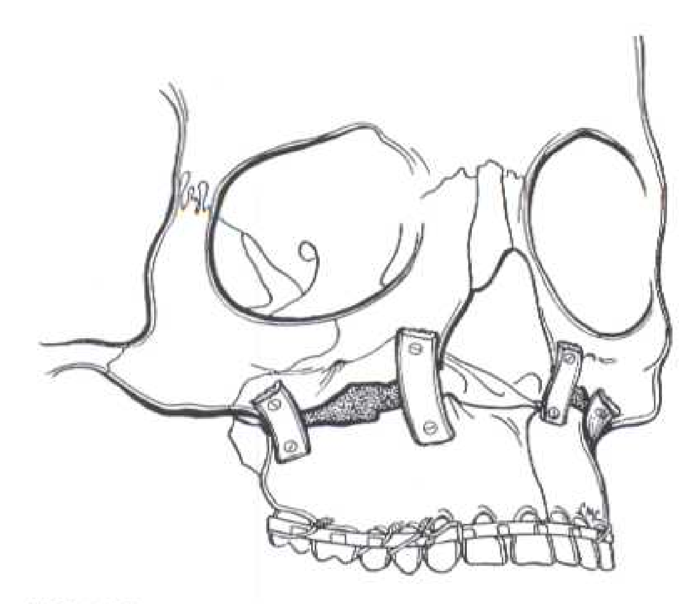


FIG. 8-32

Severe comminution and bone loss, which necessitate bone grafting, most commonly occur in the thin bone of the lower maxillae. Bone grafts provide reconstruction of the vertical buttresses (zygomaticomaxillary and pyriform) and, thereby, stabilize the severely comminuted Le Fort I fracture.

CHAPTER 7

Le Fort II (Classic)

The classic Le Fort II fracture extends from one lateral maxillary buttress superomedially across the maxilla and traverses the infraorbital rim, orbital floor, and medial orbit superomedially to the nasal bone at the nasofrontal junction. There, it crosses the midline separating the nose from the skull and makes the same path inferolaterally to the opposite lateral maxillary buttress. The fracture extends posteriorly along the perpendicular plate of the ethmoid medially and posteriorly through the posterior walls of the maxillary sinuses. The pterygoid plates are generally fractured horizontally, thus separating a pyramidally shaped midsection of the face from the remainder of the face and skull.

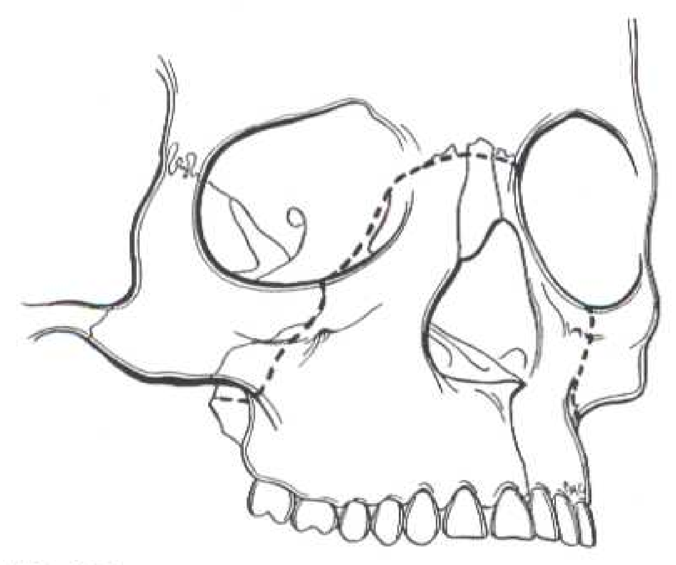


FIG. 8-33

The pure Le Fort II, as just described, is not typical today because most injuries involve some degree of comminution and other fractures, such as nasal fractures, lower maxillary fractures (Le Fort I components), and nasoethmoid complex fractures, and comminution of the maxillae and orbits are also frequently associated with the Le Fort II complex. (When a zygomatic or trimalar fracture is associated with a Le Fort II, such that a true craniofacial separation has been created, we call this a complex Le Fort III, thus naming the fracture by its most complex component.) Repair is aimed at simplifying the fracture by repairing each complex component stepwise, until the simpler more basic fracture is all that remains.

This section addresses the remaining classic Le Fort II, assuming other associated fractures have been stabilized. See the appropriate sections for each complex associated fracture.

REPAIR

Key Principles	pp. 58–61
Surgical Approaches	p. 109

Dentulous

Arch bars are first applied to the teeth, and proper occlusion is reestablished if possible. If the teeth do not come together easily, disimpaction may be carried out immediately or deferred until the fractures have been exposed.

Edentulous

An arch bar or denture (splint) containing an arch bar is fixed to the mandible with circummandibular wires. A denture (splint) containing an arch bar is positioned over the maxillary alveolus to identify the occlusal relationships. Suspension wires are not used to secure the denture. However, the denture may be screwed into the palate if desired. (A 2.0- or 2.7-mm lag screw may be used for this purpose.)

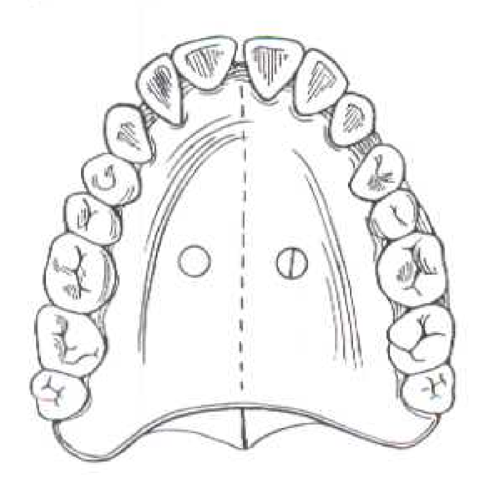


FIG. 8-34

The occlusal relationship is reestablished. If there is a gross discrepancy, the splint is removed, the midface is disimpacted, and the splint is replaced. (Attempting to disimpact the midface with the splint in place may fracture the splint.) Again, disimpaction may be deferred until after all fracture lines have been exposed.

A sublabial incision is made, and the maxillary bone is exposed, using care to avoid elevation of fractured fragments with the flap. In some cases, exact repositioning of the fragments will require exposure of the nasofrontal area. A single incision at the nasion will generally suffice, although if further frontal, nasal, or orbital exposure is required, a coronal flap may be elevated. Sometimes, it is necessary to expose one or both orbits to repair associated orbital fractures and/or for wider exposure and direct access for fixation of the infraorbital rims. This can be done by conjunctival, subciliary, or infraorbital incisions.

After the bones are satisfactorily reduced, plate fixation is carried out. If the fragments are mobile, or if countertraction is needed, an assistant supports the bones with hooks or small retractors.

If there is a strong tendency for rotation and retropositioning of the nasal root, it may be necessary to place a wire or a screw into the nasal root and pull outward, holding the bone in the proper position for fixation. Alternatively, Asch forceps may be used to disimpact the nasal root if the nasal bones are intact and continuous with the maxillae. If needed, fixation of the nasofrontal area can be accomplished with miniplates or microplates.

Option 1: A plate may be placed vertically on the midline. After bending the plate, it is held firmly in place. Each hole is drilled, and a 4- or 5-mm screw is placed.

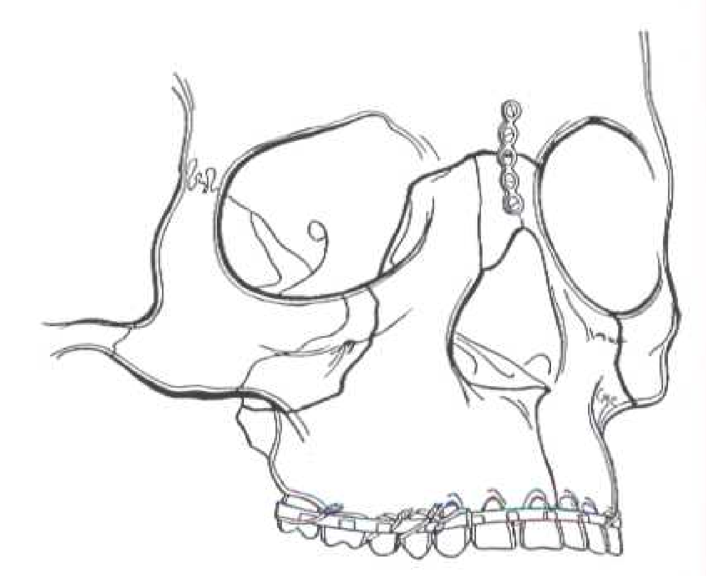


FIG. 8-35

Option 2: As an alternative, to increase the amount of stabilization and decrease the likelihood of the plate showing through the skin, two plates may be placed just off center from the frontal bone onto the dorsolateral portion of each nasal bone. A four- or five-hole straight miniplate or microplate is ideal for each side. This must be carefully bent to match the curvature of the bone. With the plate held in place, each hole is drilled and a 4- or 5-mm screw is placed.

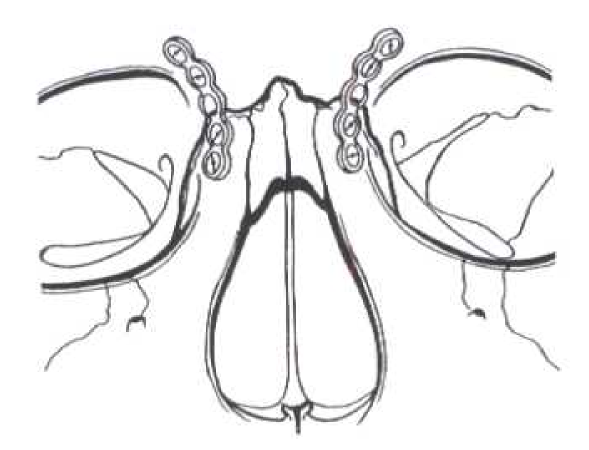


FIG. 8-36

If nasofrontal fixation has been carried out, the fracture is partially stabilized, and care must be taken to avoid excessive manipulation at the zygomaticomaxillary level. Alignment is adjusted along the zygomaticomaxillary buttresses bilaterally in preparation for rigid fixation. Alignment of the infraorbital rims is assessed through the sublabial approach. If orbital exploration is required, direct exposure of the rim(s) allows for fixation with wires or microplates if needed. A solid fixation along the zygomaticomaxillary buttress ensures rigid stabilization of the Le Fort II fracture. Multiple screw fixation points are desirable; therefore, the L, J, X, or three-dimensional type of plate is selected if there is enough bone present. This should allow for placement of at least two, but preferably three or more, screws in each segment. A template may be used, or the plate may be bent without using a template. Great care must be taken to match the plate to the bone as accurately as possible with as few bends as possible so that a strong and dependable fixation results. Each hole is drilled, and a screw is placed before proceeding to the next hole. This is repeated along the contralateral zygomaticomaxillary buttress.

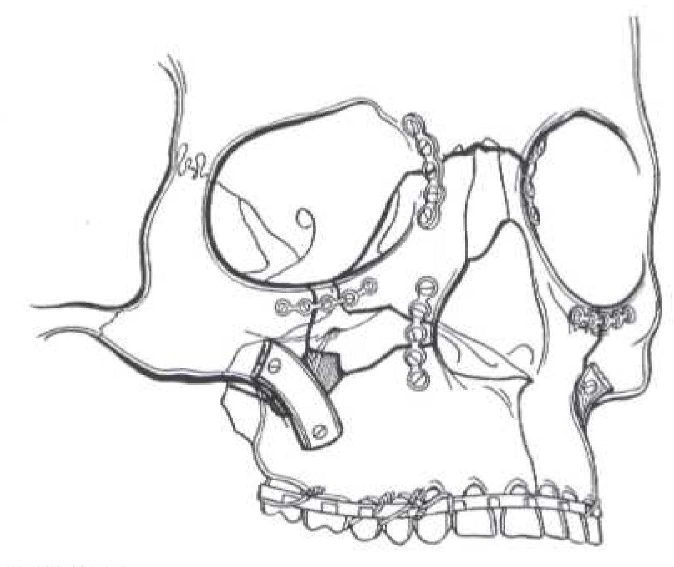


FIG. 8-37

It is not uncommon to find significant comminution in the anterior maxillary areas, thus creating a more complex fracture then the simple Le Fort II, as described by Le Fort (and as accomplished intentionally in orthognathic surgery).

Comminuted segments of bone can often be reconstructed if the pieces are present and strong enough. An assistant may hold the fragments up with a Trach hook while the surgeon places miniplates over the fragments and stabilizes them to each other. Sometimes, multiple small fragments may be wired together. It is then easier to join these partially stabilized bone fragments together with one or more miniplates or three-dimensional microplates. After fixation of the fractures has been completed, the wounds are irrigated, drained when appropriate, and closed.

DEFECTS

Key Principles	p. 50
Surgical Approaches	p. 109

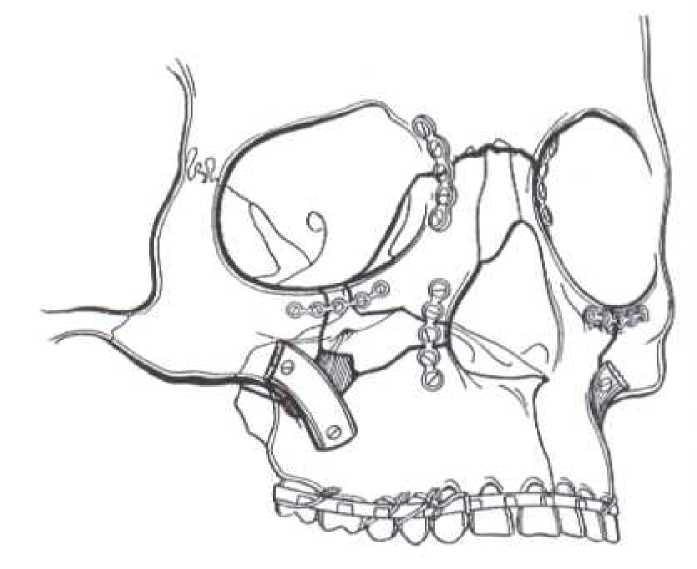


FIG. 8-38

When bridging gaps greater than 5 to 10 mm, bone grafting is advised for increased stability during healing and to ensure a greater likelihood of bony union and a long-term stable result. Rib or calvarium is generally selected. The appropriate graft is harvested and shaped so that the bone graft overlaps the bone on either side of the defect. Lag screws may now be placed through each end of the graft and into the bone underneath. This serves to stabilize both the graft and the fracture. The graft itself serves as the rigid fixation device, thereby both bridging and stabilizing the fracture at once.

Severe comminution and bone loss, which necessitates bone grafting, occur most commonly in the thin bone of the lower maxillae. Bone grafts provide reconstruction of the vertical buttresses (zygomaticomaxillary and nasomaxillary) and thereby stabilize the severely comminuted Le Fort II fracture.

CHAPTER 8

Le Fort III

The classic Le Fort III fracture or "craniofacial separation" traverses the lateral and medial orbital walls, the nasofrontal area, the nasal septum, and the zygomatic arches, completing the craniofacial separation posteriorly through the posterior orbital floors and pterygoid plates. This "pure" form of the Le Fort III is rarely seen today; most are more complex, often including multiple maxillary fractures, zygomaticomaxillary fractures, and nasal and nasoethmoid complex fractures.

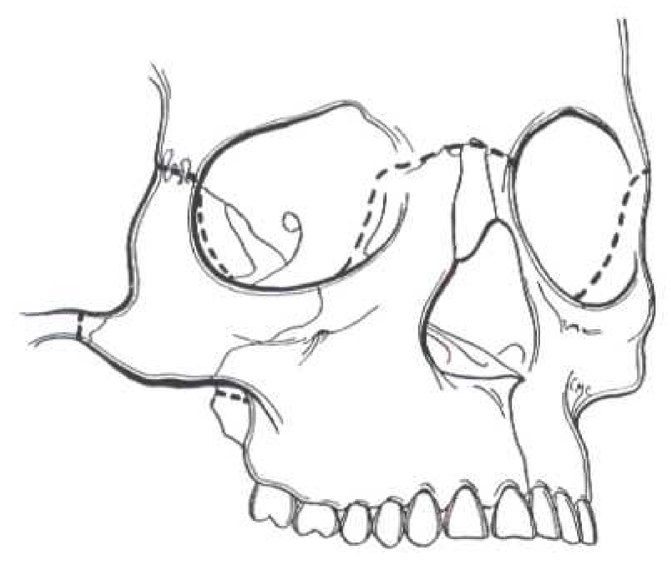


FIG. 8-39

Repair of the classic Le Fort III is described. Note that, in a more complex fracture, after the zygomatic bones and nasal bones are fixed to the skull, any remaining fractures would be Le Fort I and II fractures, and they are repaired as such.

REPAIR

Key Principles	pp. 58–61, 62
Surgical Approaches	pp. 87, 109

Dentulous

Arch bars are first applied to the teeth and proper occlusion is reestablished if possible. If the teeth do not come together easily, disimpaction may be carried out immediately or deferred until the fractures have been exposed.

Edentulous

An arch bar or denture (splint) containing an arch bar is fixed to the mandible with circummandibular wires. A denture (splint) containing an arch bar is positioned over the maxillary alveolus to identify the occlusal relationships. Suspension wires are not used to secure the denture. However, the denture may be screwed into the palate if desired. (A 2.0- or 2.7-mm lag screw may be used for this purpose.)

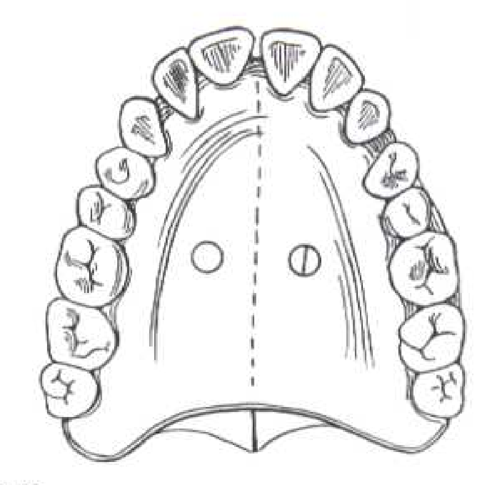


FIG. 8-40

The occlusal relationship is reestablished. If there is a gross discrepancy, the splint is removed, the midface is disimpacted, and the splint is replaced. (Attempting to disimpact the midface with the splint in place may fracture the splint.) Again, disimpaction may be deferred until after all fracture lines have been exposed.

Simple. When the Le Fort III fracture is relatively nondisplaced, particularly the zygomatic components, it may be possible to stabilize the zygomas to the frontal bones by using a limited approach, thereby converting the Le Fort III to a Le Fort II. This is more likely when dealing with a unilateral Le Fort III, which in fact may be more like a Le Fort II with an associated zygomatic (tripod) fracture. Note, however, that any significant displacement of the zygomatic arch, particularly with disruption of the zygomaticomaxillary elements makes proper realignment of the zygomaticofrontal relationship unlikely through a limited approach, and wide exposure using a coronal flap is recommended. Keep in mind also that, as noted earlier, in most Le Fort III fractures, there is indeed disruption of the zygomaticomaxillary area. This makes realignment of the zygomatic position relative to the stable cranial bones more difficult than that of the tripod fracture in which the stable maxilla provides additional information for zygomatic repositioning.

If a limited approach is selected, then the frontozygomatic portion of the fracture is exposed by using a brow incision or an upper lid incision. Bone is exposed above and below the fracture. Exposure of the lateral orbital wall provides an additional reference area for bone alignment and, thereby, increases the likelihood of proper reduction. After proper realignment is ensured, a miniplate (neutral or compression) is applied along the strong frontozygomatic vertical buttress.

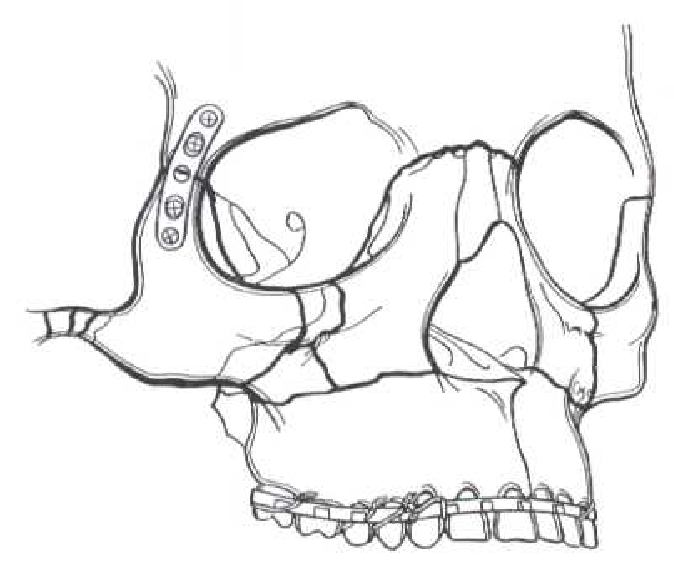


FIG. 8-41

If this has been successfully and satisfactorily accomplished, the patient is now left with a Le Fort II fracture. Refer to the section on Le Fort II fractures for the remainder of the repair.

Complex. In most situations, the craniofacial separation provides few landmarks for proper facial bone realignment. Therefore, maximal exposure to maximize the number of reference points is generally used.

A coronal flap is elevated and brought inferiorly to expose the nasal root, lateral orbital rims, and zygomatic arches. The lateral orbital walls usually are also exposed.

The sublabial incision is made, thereby exposing the maxillary components of the fractures (except in the rare situation in which a pure Le Fort III has occurred). Care is used to avoid elevating the fractured fragments with the flap. (If disimpaction has not been completed or was initially ineffective, it is carried out at this time. When using the Rowe midfacial disimpactors, care must be used not to pull the midfacial bones superiorly because dural and even brain injury and blindness could result. Occlusion is then stabilized with IMF.)

The nasofrontal area is fixed to prevent rotation of the midface. This may be wired initially if the exact position is uncertain.

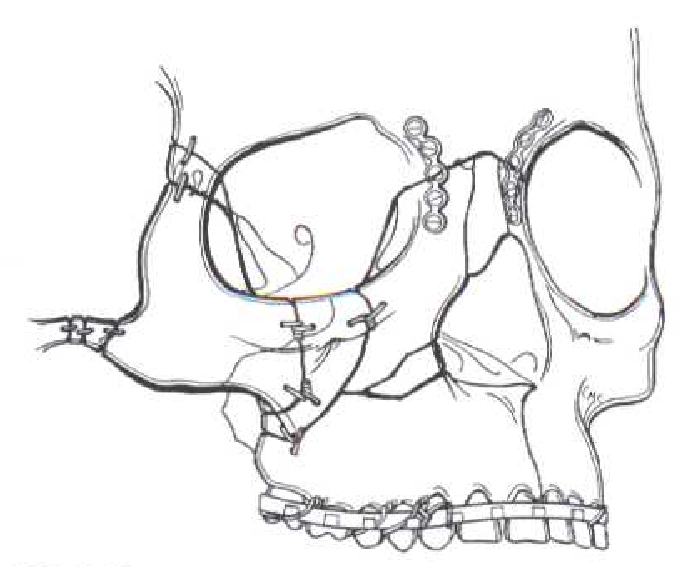


FIG. 8-42

When a nasoethmoid complex fracture is present, a bone graft may be required. This is performed after stabilization of the midface.

Each zygoma is repositioned, using in typical sequence the fragments of the zygomatic arch, the frontozygomatic area, the lateral orbital wall, and the zygomaticomaxillary area (if possible) as reference points.

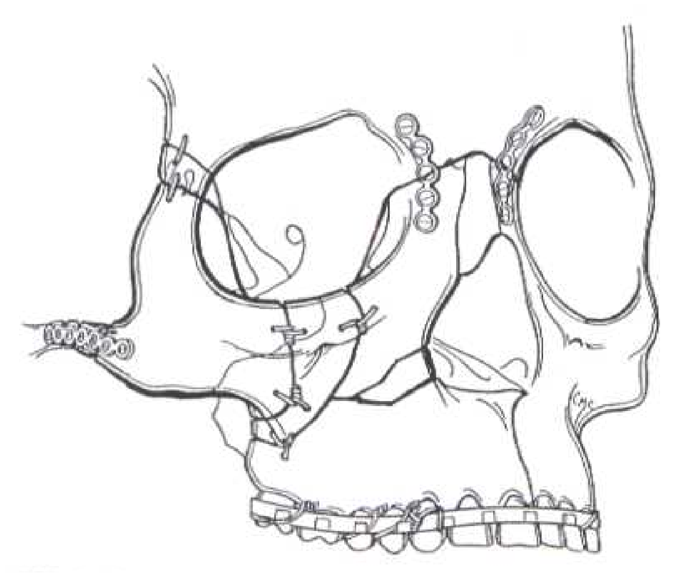


FIG. 8-43

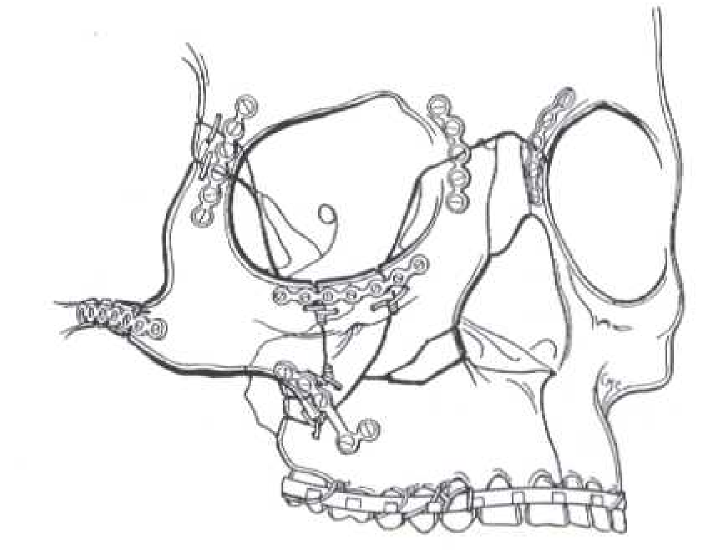


FIG. 8-45

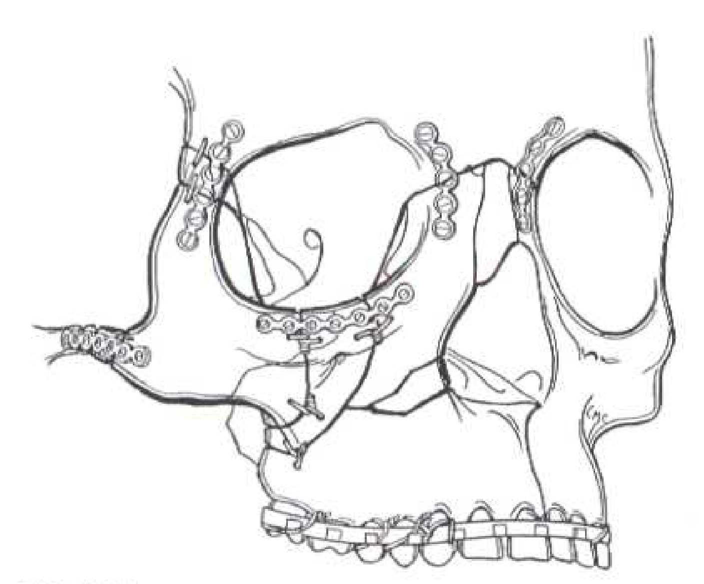


FIG. 8-44

If the nasal root has been stabilized, then fixation of the zygomatic bones to the skull constitutes repair of the craniofacial separation and, thus, stabilization of the Le Fort III. Because most fractures seen today are not pure Le Fort fractures, Le Fort I and II components and nasoethmoid and orbital fractures often remain. Their repair is discussed in the appropriate sections.

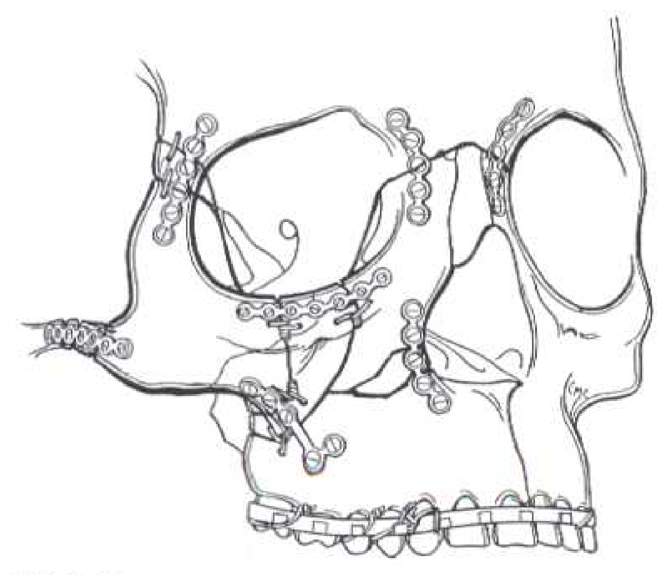


FIG. 8-46

After fixation of the fractures has been completed, the wounds are irrigated, drained when appropriate, and closed.

DEFECTS

Key Principles	p. 50
Surgical Approaches	p. 109

When bridging gaps greater than 5 to 10 mm, bone grafting is advised for increased stability during healing and to ensure a greater likelihood of bony union and a long-term stable result. Rib or calvarium is generally selected. The appropriate graft is harvested and shaped so that the bone graft overlaps the bone on either side of the defect. Lag screws may now be placed through each end of the graft and into the bone underneath. This serves to stabilize both the graft and the fracture. The graft itself serves as the rigid fixation device, thereby both bridging and stabilizing the fracture at once.

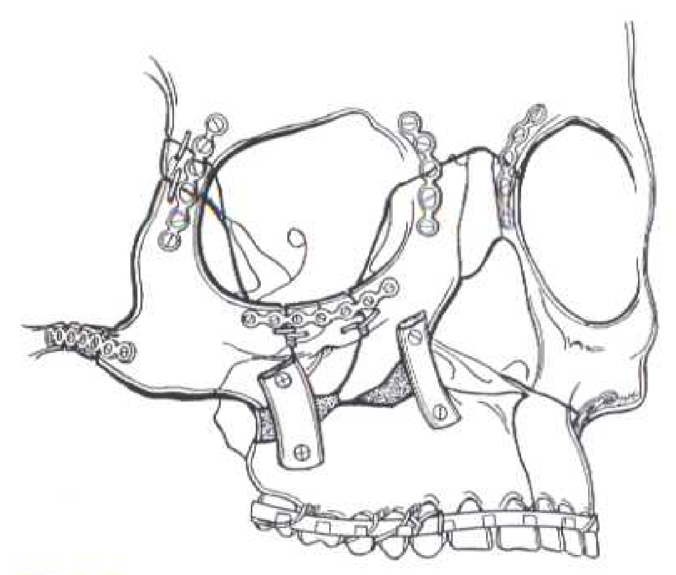


FIG. 8-47

Severe comminution and bone loss, which necessitate bone grafting, are most commonly seen in the thin bone of the lower maxillae. Bone grafts provide reconstruction of the vertical buttresses (zygomaticomaxillary and nasomaxillary) and, thereby, stabilize the severely comminuted Le Fort I, II, and III fractures.

CHAPTER 9

Severe Comminution of the Maxillae (Le Fort I, II, and III)

When the maxillary bones are severely comminuted, it is hard to determine the correct spatial repositioning of the bones. IMF is key to reestablishing the occlusal relationship. If at least one vertical buttress is present on each side, rigid fixation of these with miniplates or three-dimensional microplates will reestablish facial height. If all the vertical buttresses are shattered, the vertical height of the mandible helps to define the facial height.

If bilateral subcondylar fractures of the mandible are also present, then facial foreshortening can easily result. It is imperative in this situation to open and repair at least one if not both subcondylar fractures prior to fixing the maxillae.

When possible, the comminuted fragments of maxilla are pieced together and stabilized with wires to reestablish the alignment as much as possible. Miniplates or three-dimensional microplates are then used to fix the most solid bone inferiorly (above the alveolus) to the solid bone above, fixing intervening fragments to the plates with screws whenever possible. If the intervening fragments are too shattered to be saved and fixed even with wires, then the area should be treated as a defect, and a bone graft technique should be used.

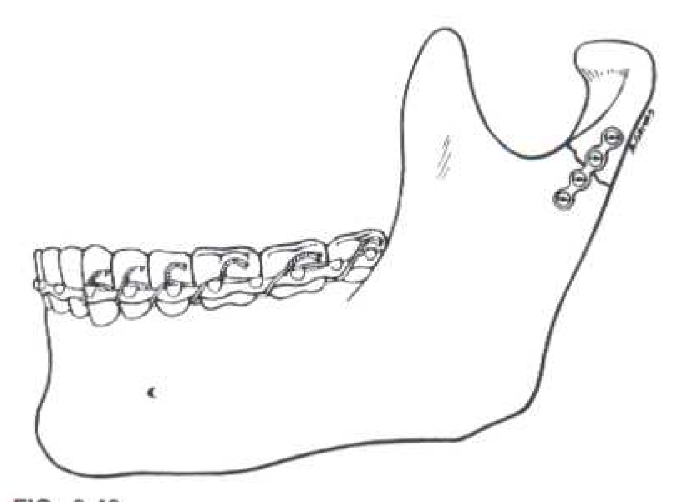


FIG. 8-48

CHAPTER 10

Split Palate

The presence of a split palate in combination with bilateral Le Fort fractures makes proper realignment of the fragments exceedingly difficult because IMF will tend to rotate the bones and direct the teeth lingually. This problem is magnified tremendously if a mandible fracture is also associated, particularly a symphyseal fracture. The use of a denture (if the patient had one) or a splint is advised in this situation to provide a guide for the proper bony reduction.

When a mandible fracture is present, it is generally repaired first. The repaired mandible will then serve to guide the positioning of the maxillary alveolar fragments. If need be, a palatal flap may be elevated, and the palatal fracture may be repaired with a miniplate or a three-dimensional microplate.

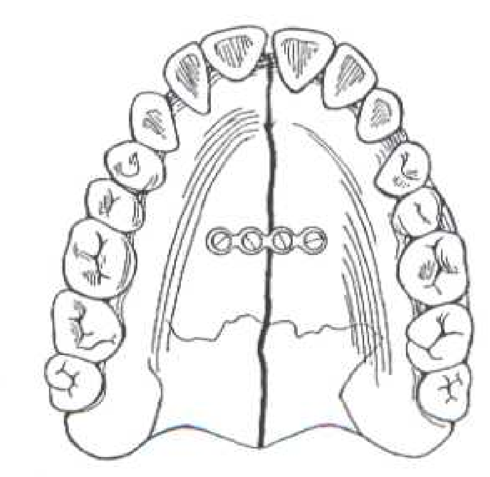


FIG. 8-49

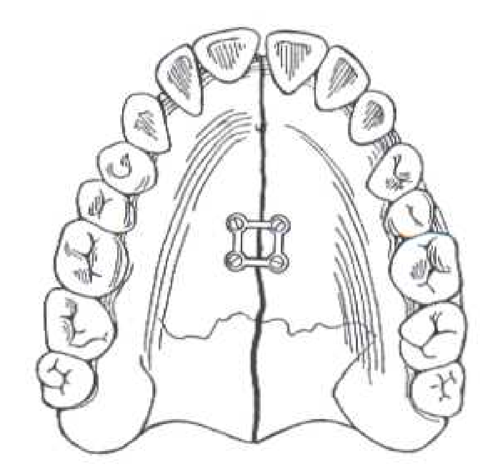


FIG. 8-50

If a splint or denture is used to reduce the maxillary fragments, then a miniplate is placed across the anterior maxilla, stabilizing the palatal fracture.

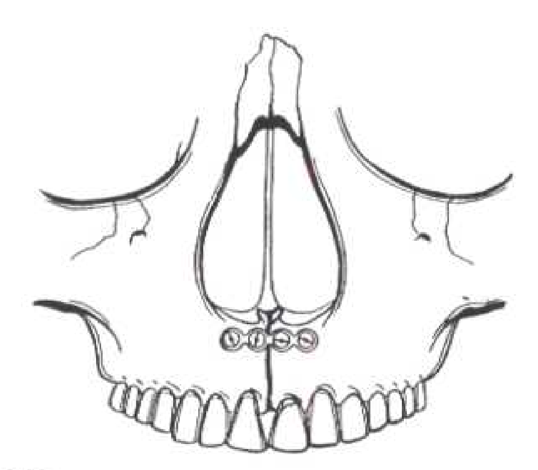


FIG. 8-51

(The splint may be fixed to the palate on each side with screws, overdrilling the holes in the splint [gliding holes], so that a lag screw fixation of the splint to the palate is accomplished.)

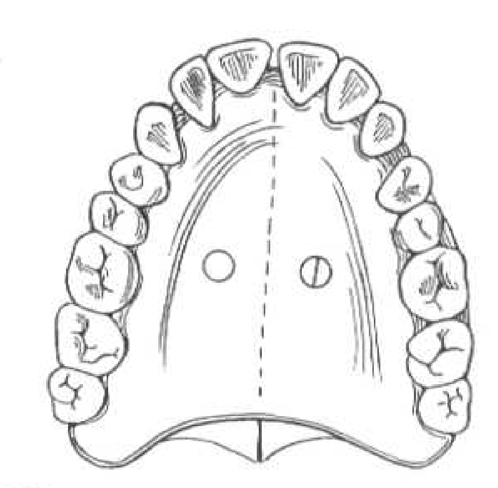


FIG. 8-52

After the split palate has been stabilized, the Le Fort fractures are repaired as outlined earlier.

UNIT IX

Midface Orthognathic and Craniofacial

UNIT OUTLINE

NOTE: *The surgeon should review the literature carefully regarding the use of rigid fixation and facial growth and development. In particular, the use of plates across sutures should be left to the experience and discretion of the surgeon.*

CHAPTER 1

Midface Orthognathic

LE FORT I OSTEOTOMY

Key Principles	pp. 58–61
Surgical Approaches	p. 109

1. All osteotomies have been completed, and the maxilla has been completely mobilized and repositioned.

2. Plates are placed on the medial and lateral buttresses and contoured exactly to the surface of the maxilla on each side of the osteotomy. The holes are drilled in the neutral position, and the screws are inserted. Care must be taken to drill the holes greater than 5 mm from the root apices. The length of the horizontal step in the miniplates must equal the amount of maxillary movement; otherwise, malocclusion will result.

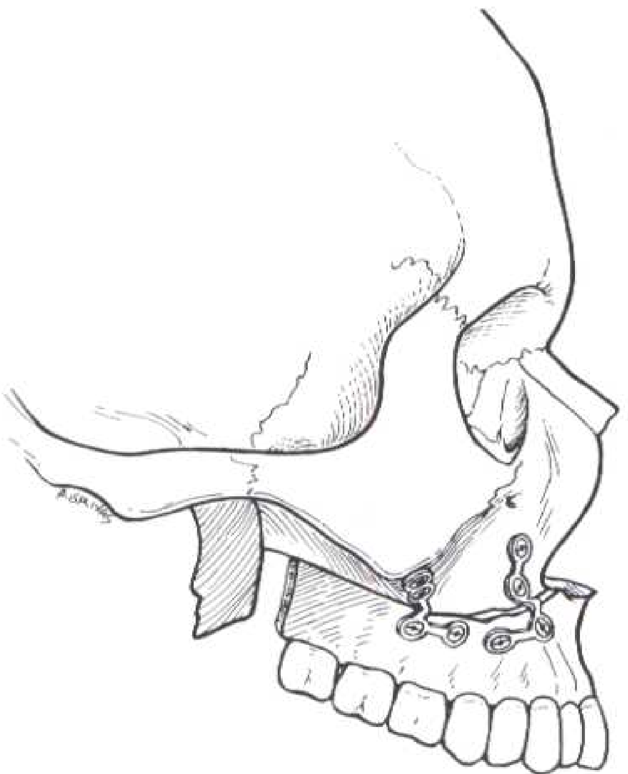


FIG. 9-1

3. The medial and lateral buttresses provide thicker bone for screw placement; therefore, plates should be applied in these areas.

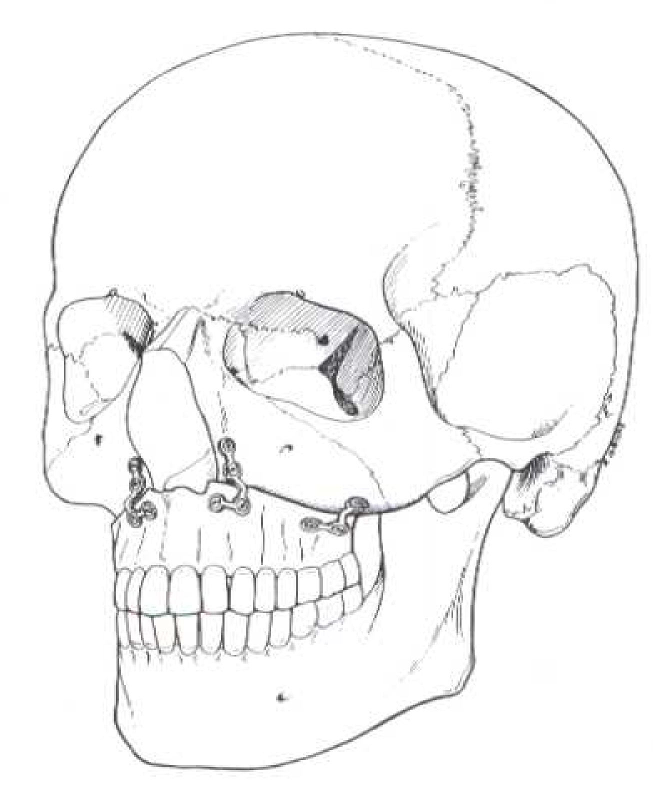


FIG. 9-2

4. As an alternative to miniplates, a single three-dimensional plate may also be used to stabilize the maxilla. The plate should span from the medial to the lateral buttress and be anchored in this thicker bone.

5. If interpositional bone grafting is needed to correct vertical maxillary deficiency, then bridging plates can be used to stabilize the osteotomy.

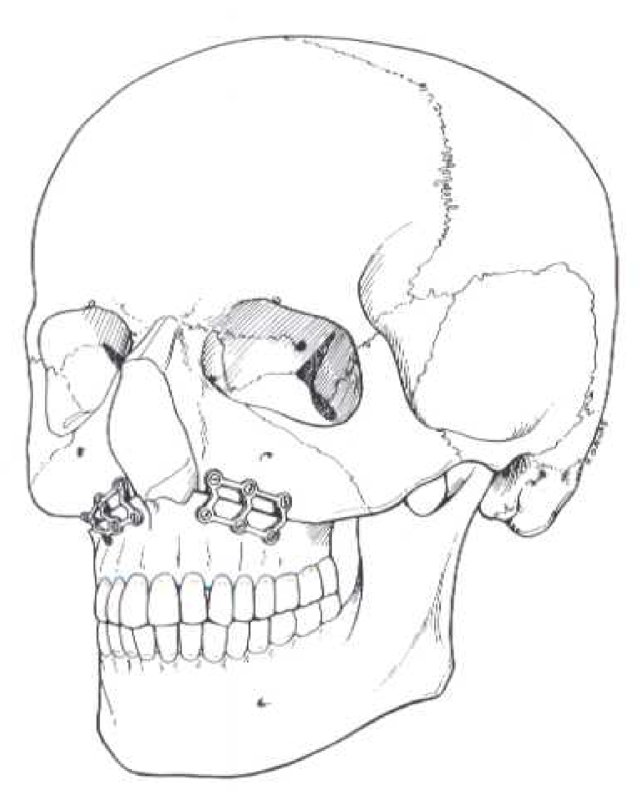


FIG. 9-3

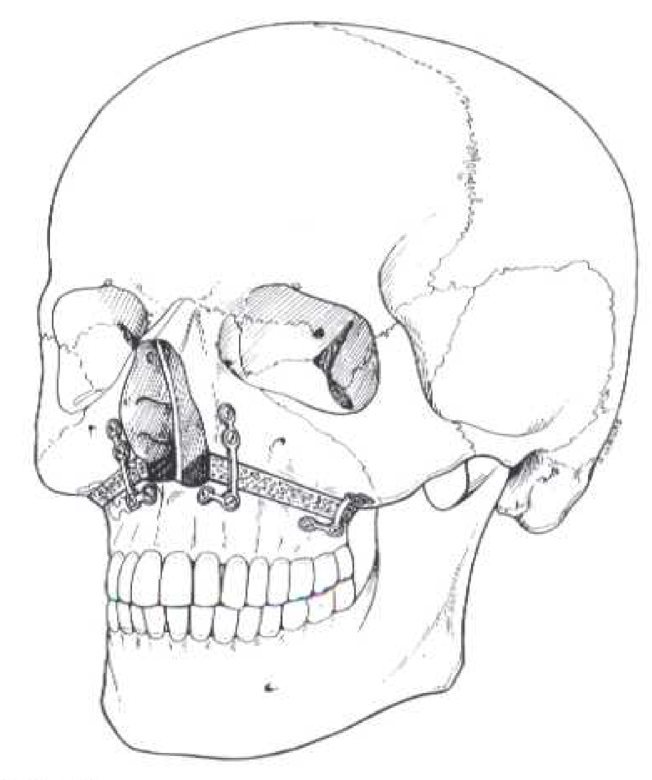


FIG. 9-4

LE FORT II OSTEOTOMY

Key Principles	pp. 58–61
Surgical Approaches	pp. 87, 109, 115, 120, 123

1. The osteotomies have been completed, and the maxilla is completely mobilized and repositioned.

2. Miniplates are contoured to the surface of the lateral buttress, holes are drilled, and the screws are placed. Microplates are placed along the infraorbital rim.

3. Additional stabilization can be gained by placing plates at the nasofrontal suture with a bone graft.

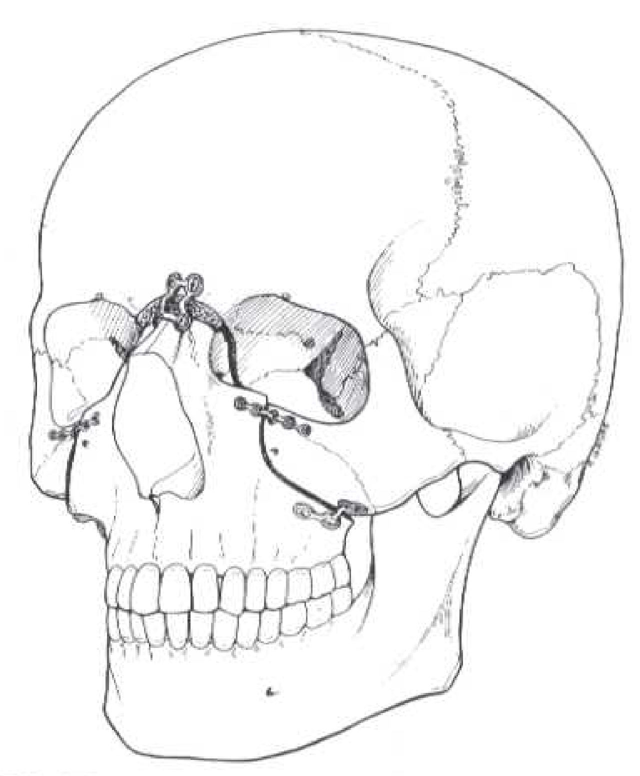


FIG. 9-5

LE FORT III OSTEOTOMY

Key Principles	pp. 58–61
Surgical Approaches	pp. 87, 109

1. The osteotomies have been completed, and the midface is completely mobilized and repositioned.

2. Plates are contoured exactly to the surface of the frontozygomatic and nasofrontal sutures and the zygomatic arch. With the bone grafts in position, the holes are drilled, and the screws are placed.

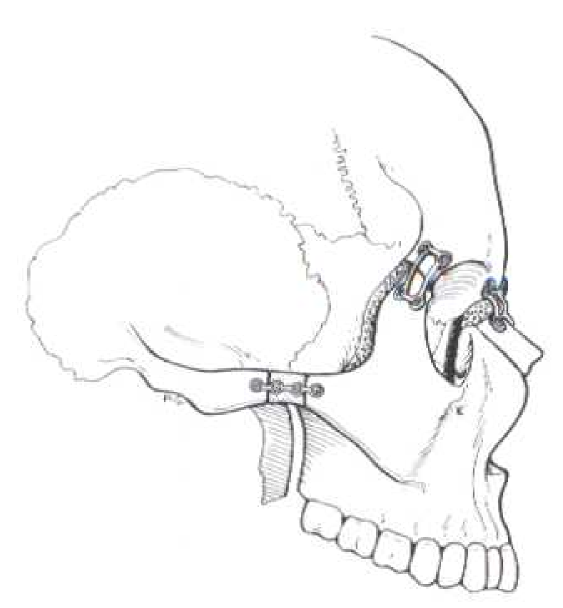


FIG. 9-6

3. Low-profile plates should be used at the frontozygomatic suture because the skin is thin and underlying fixation devices are easily palpable. Alternatively, a plate may be placed in the temporal fossa.

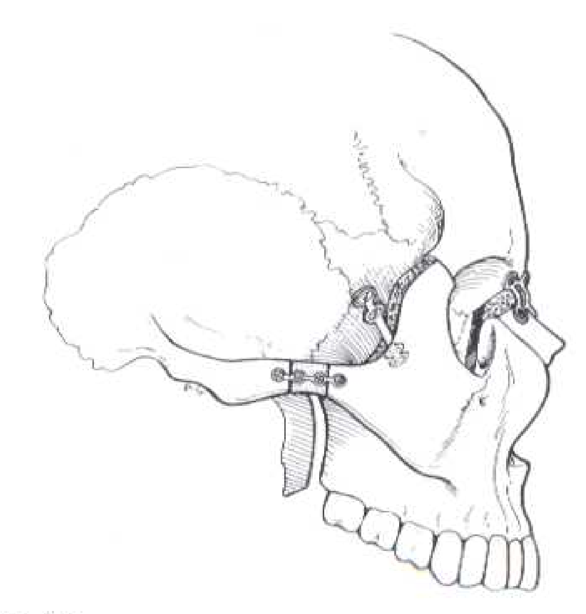


FIG. 9-7

LE FORT III PLUS I OSTEOTOMY

Key Principles	pp. 58–61
Surgical Approaches	pp. 87, 109

1. The osteotomies have been completed, and the midface is mobilized and repositioned. The two midfacial segments are stabilized in their respective positions.

2. Plates are contoured to the surface at the nasofrontal and frontozygomatic sutures and the zygomatic arch. With bone grafts in position, the holes are drilled, and the screws are placed.

3. Plates are contoured to the medial and lateral buttresses, the holes are drilled in a neutral position, and the screws are placed.

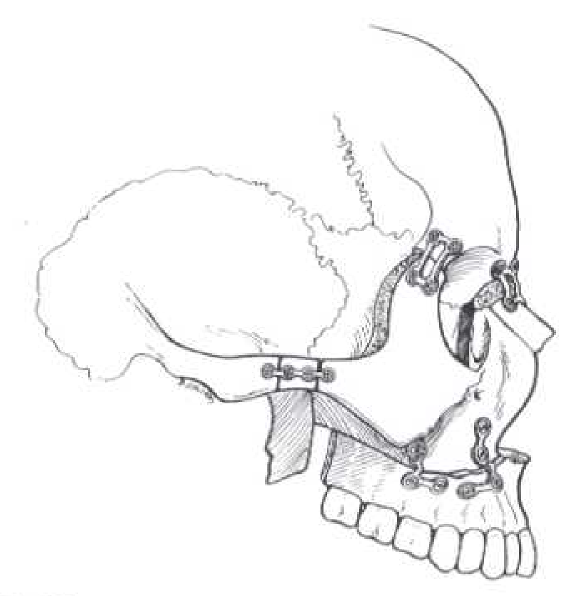


FIG. 9-8

TOTAL MALAR OSTEOTOMY

Key Principles	pp. 58–61
Surgical Approaches	pp. 87, 109, 115, 120, 123

1. The osteotomies are completed, and the zygoma is mobilized and correctly repositioned.

2. Plates are contoured to the underlying bone at the frontozygomatic suture, the inferior orbital rim, and the zygomatic arch. Low-profile plates should be used to avoid palpable fixation devices. The surgeon may choose not to place plates at all three locations. This decision should be based on the stability of the repositioned zygoma and the operator's experience.

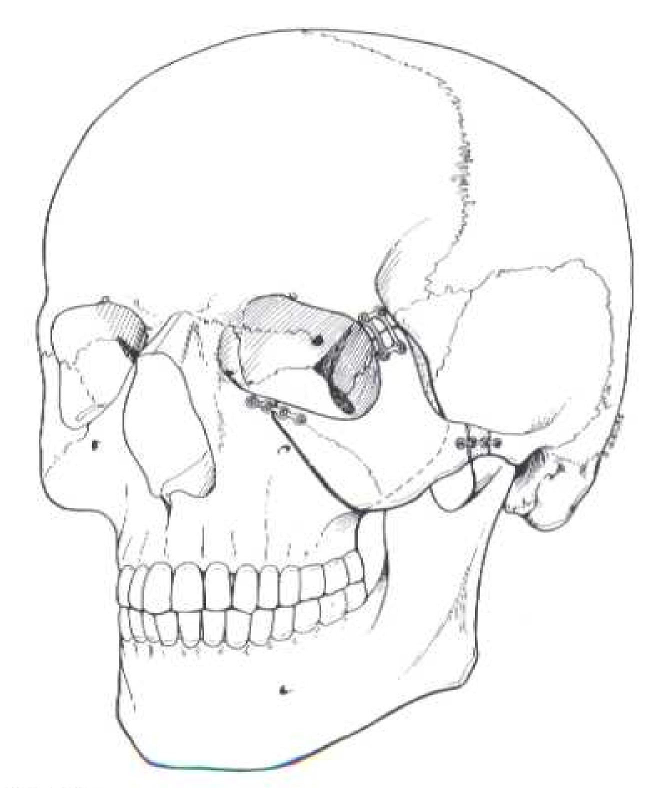


FIG. 9-9

CHAPTER 2

Craniofacial

FRONTO-ORBITAL OSTEOTOMY (BILATERAL)

Key Principles	pp. 58–61
Surgical Approaches	p. 87

1. The bifrontal craniotomy has been performed, and the bone flap is removed. A tongue-in-groove osteotomy is created to allow bone contact in the temporal fossa.

2. After the orbital bar is remodeled, it is placed in its new position. A plate is contoured to the underlying bone in the temporal fossa. The inferior portion of the plate should be anchored in the greater wing of the sphenoid, which provides a solid foundation for the screws.

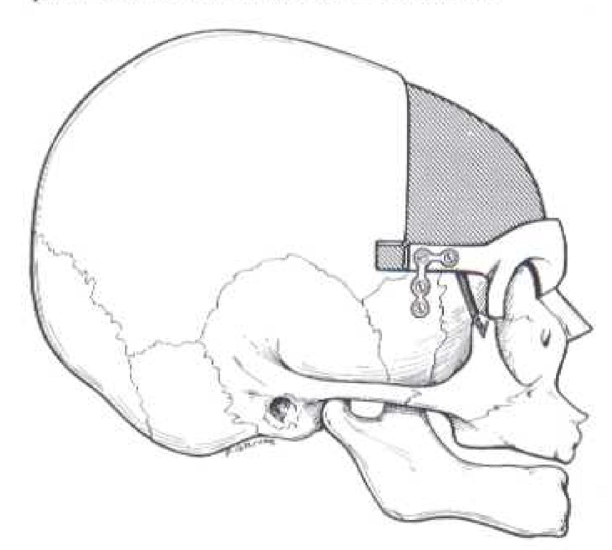


FIG. 9-10

3. After the orbital bar is secured, the craniotomy bone flap is remodeled and placed in its new position. Microplates are used to secure the bone flap to the orbital bar.

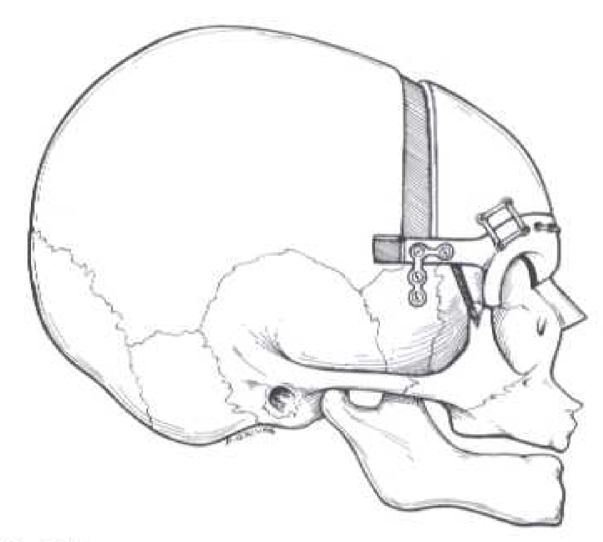


FIG. 9-11

4. If the bone flap and the orbital bar have been sectioned, then plates should span those osteotomy sites.

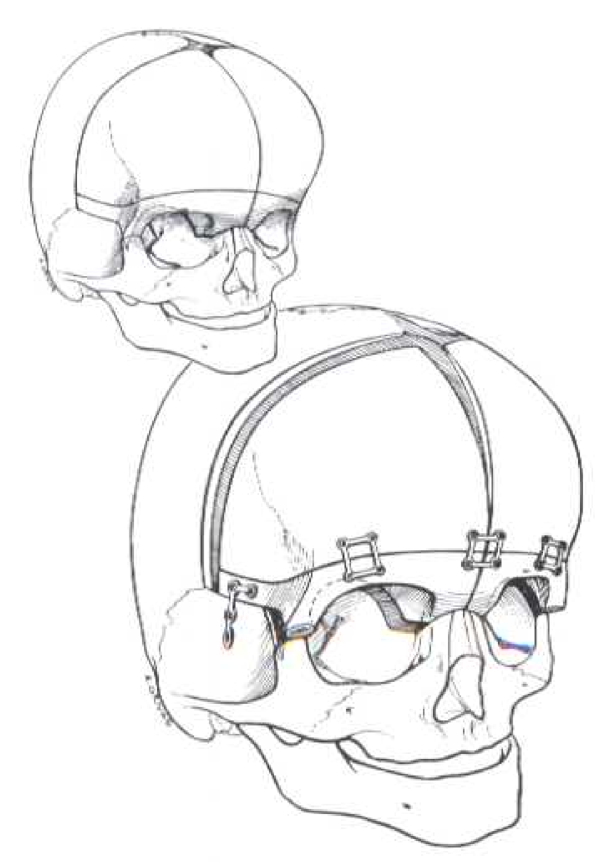


FIG. 9-12

FRONTO-ORBITAL OSTEOTOMY (UNILATERAL)

Key Principles	pp. 58–61
Surgical Approaches	p. 87

1. The frontal craniotomy has been performed, and the bone flap is removed. A tongue-in-groove osteotomy is created to allow adequate bone contact in the temporal fossa.

2. After the orbital bar is remodeled, it is placed in its new position. A plate is contoured to the underlying bone in the temporal fossa. The inferior portion of the plate should be anchored in the greater wing of the sphenoid, which provides a solid foundation for the plate.

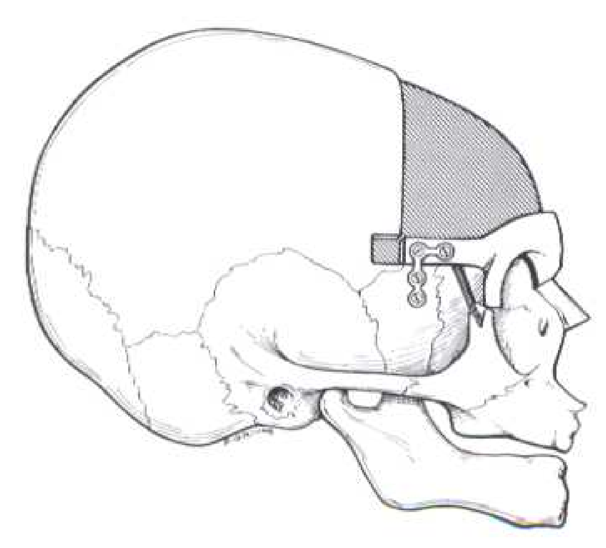


FIG. 9-13

3. After the orbital bar has been secured, the craniotomy bone flap is remodeled and placed in its new position. Microplates are used to secure the bone flap to the orbital bar.

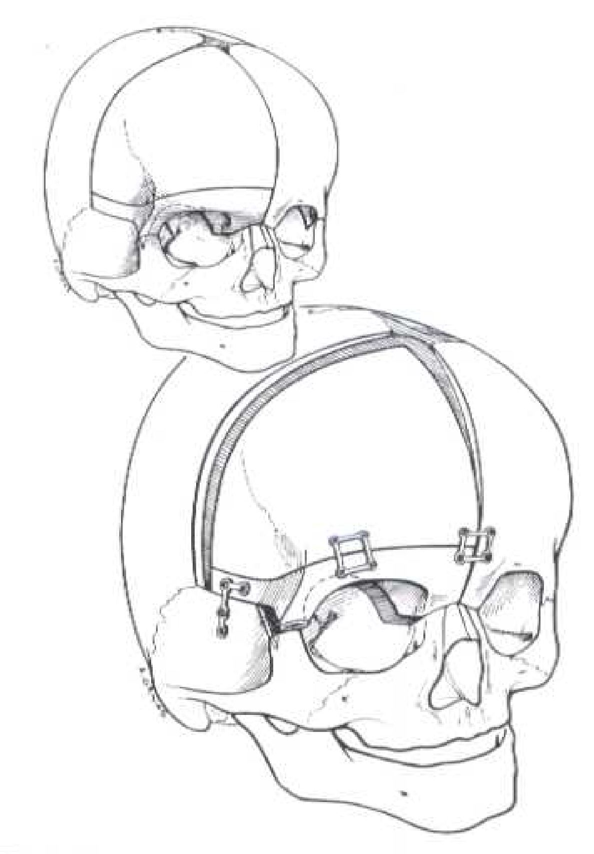


FIG. 9-14

TRIGONOCEPHALY CORRECTION

Key Principles	pp. 58–61
Surgical Approaches	p. 87

1. The bifrontal craniotomy has been performed, and the bone flap is removed. The orbital osteotomies have been completed, and the fronto-orbital bar is removed.

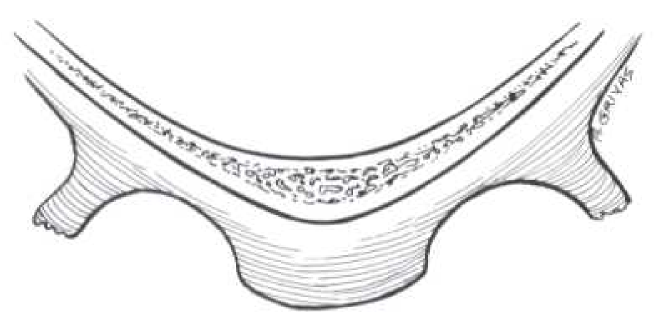


FIG. 9-15

2. The inner table of the midline 1.0 cm of the fronto-orbital bar is removed, and the bar is fractured through the fused metopic suture. The repositioned halves are held in position by a microplate across the suture.

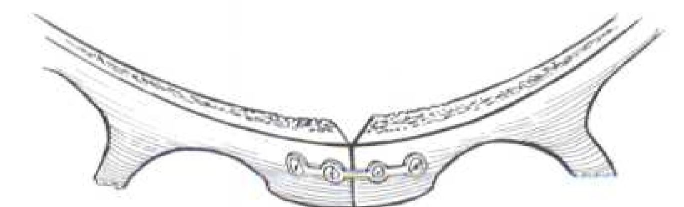


FIG. 9-16

3. Alternatively, the graft taken from the inner table is placed across the fracture and lag screwed into position.

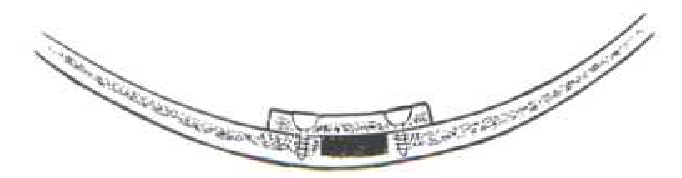


FIG. 9-17

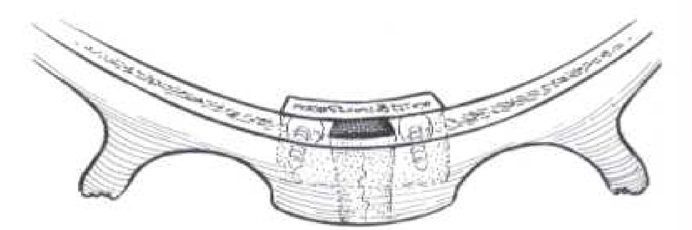


FIG. 9-18

4. If the lateral portion of the bar requires remodeling, greenstick fractures are created, the bone is remodeled, and microplates are used to stabilize the bone segments.

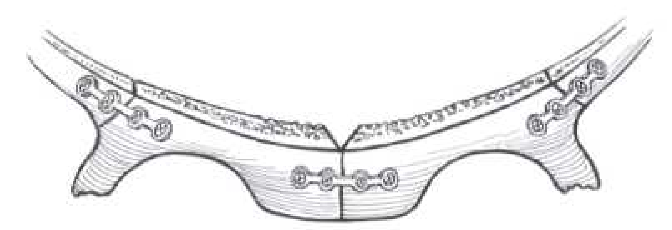


FIG. 9-19

5. The remodeled fronto-orbital bar is replaced, and the tongue-in-groove osteotomy is secured with plates. Following this, the remodeled frontal bone flap is secured to the bar with microplates.

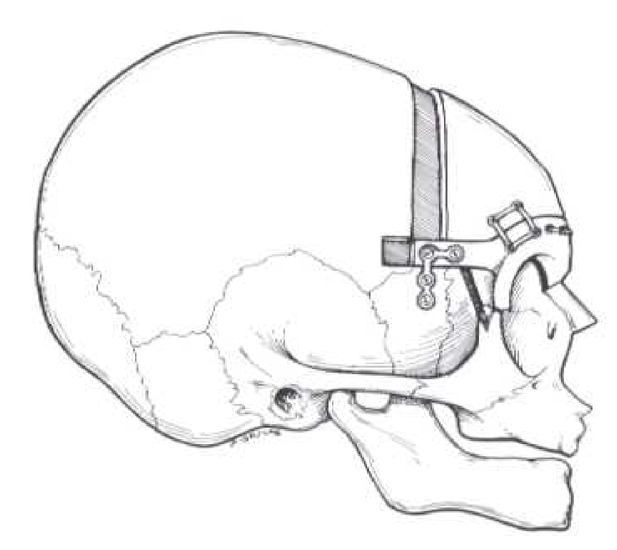


FIG. 9-20

ORBITAL HYPERTELORISM CORRECTION

Key Principles	pp. 58–61
Surgical Approaches	pp. 87, 109, 115, 120, 123

1. The craniotomy and the four-quadrant osteotomies have been performed, and the orbits are mobilized. If an encephalocele is present, the midportion of the frontal bar and nasal bones may be removed, allowing excision of ectopic brain tissue. The bone is replaced and secured with microplates.

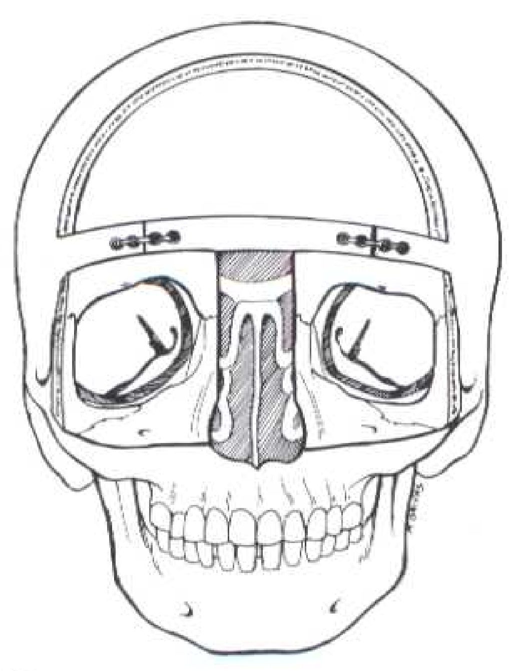


FIG. 9-21

2. After medial translocation of the orbits, microplates are used to secure the orbital segments to the frontal bar. Bone grafts are placed at the lateral orbital walls and the nasal bones. These are secured with lag screws, miniplates, or microplates, depending on the degree of stability required.

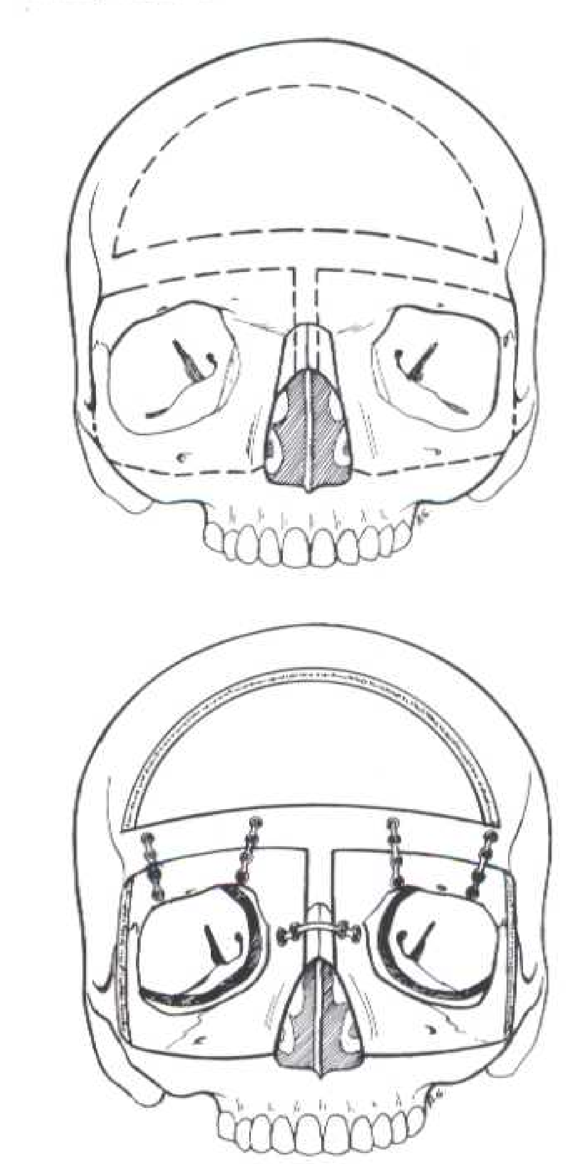


FIG. 9-22

3. After the orbital bar is secured, the frontal bone flap is replaced and secured with microplates. Various plates that may be used are shown.

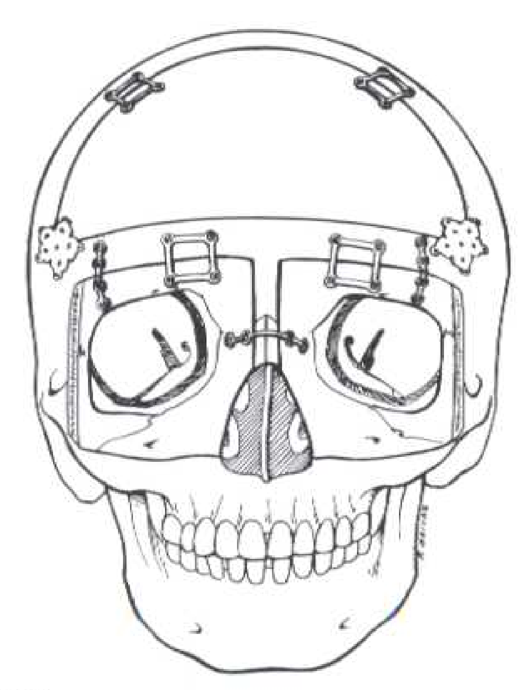


FIG. 9-23

FACIAL MONOBLOC

Key Principles	pp. 58–61
Surgical Approaches	p. 87

1. The bifrontal craniotomy has been performed, the midface osteotomies are created, and the midface is mobilized and secured in its new position. A bone graft is placed in the defect of the zygomatic arch and secured with a microplate.

   (Option 1) The plate secures the tongue-in-groove osteotomy to the greater wing of the sphenoid.

   (Option 2) The plate spans the gap in the temporal fossa and connects the lateral orbit to the greater wing of the sphenoid.

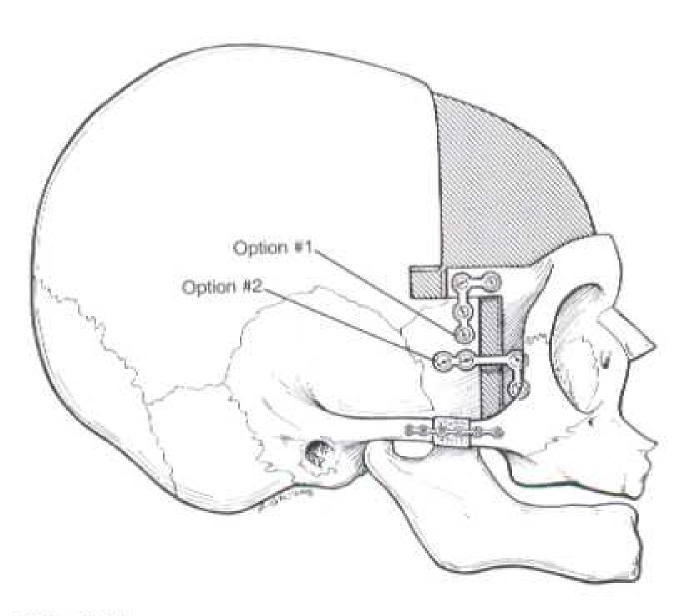


FIG. 9-24

2. The craniotomy bone flap is remodeled and placed in its new position. The bone flap is secured to the frontal bar with microplates (Options 3 and 4).

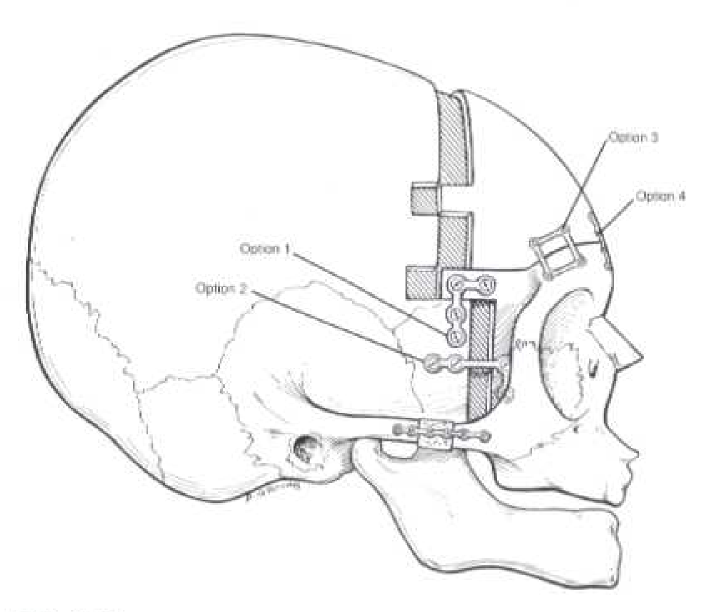


FIG. 9-25

3. If further stabilization is necessary, plates can be placed across the gap at the coronal suture.

   (Option 5) A standard miniplate spans the defect.

   (Option 6) A microplate is used to span the defect.

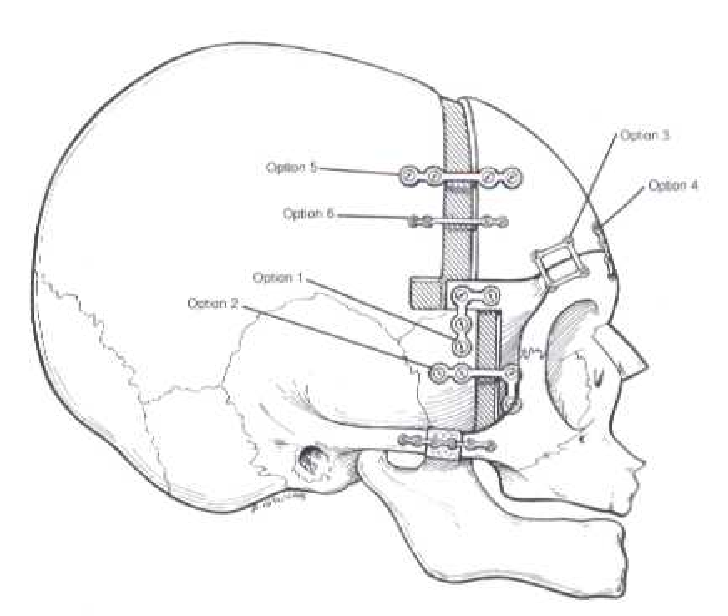


FIG. 9-26

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ISBN 0-7817-0016-7
Order Code 2532